PETROLEUM REFINER

SPECIALIZED FOR THE OIL REFINING INDUSTRY, INCLUDING PETRO-CHEMICAL ENGINEERING, PETROLEUM SYNTHETICS AND NATURAL GASOLINE

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Editor

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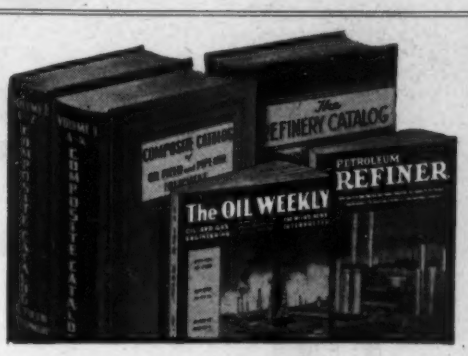

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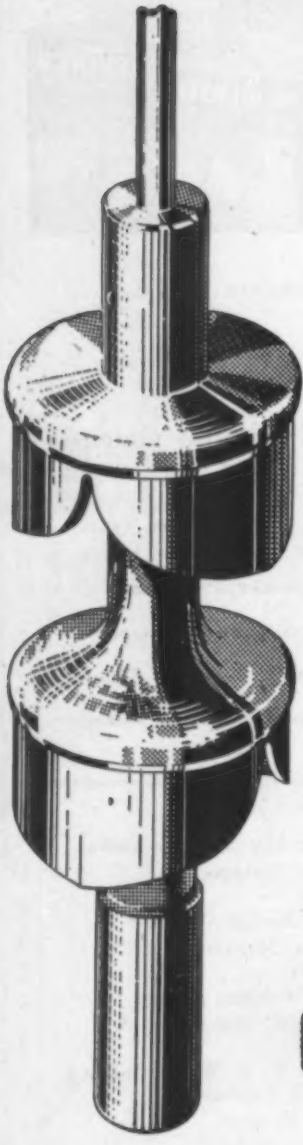

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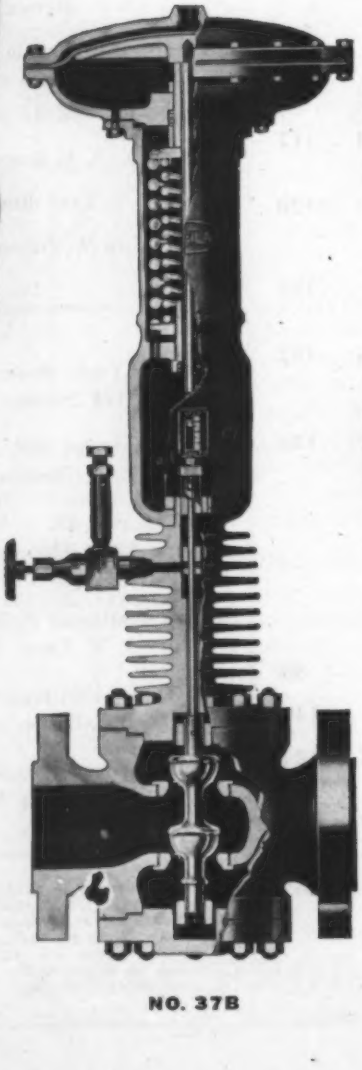

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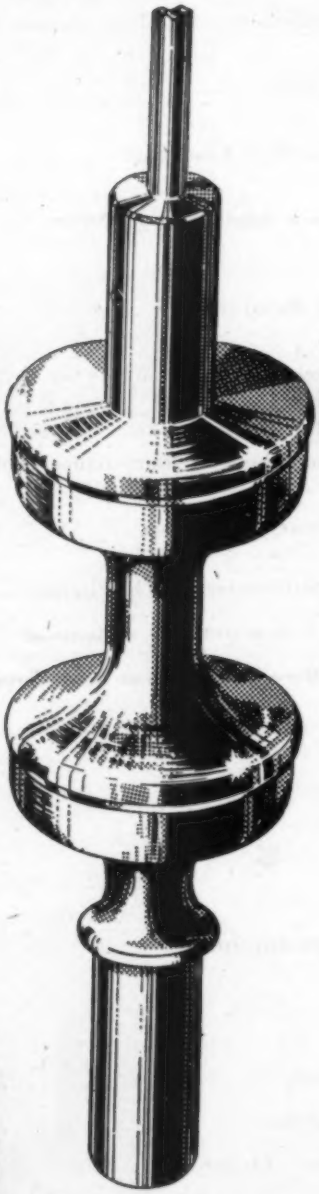

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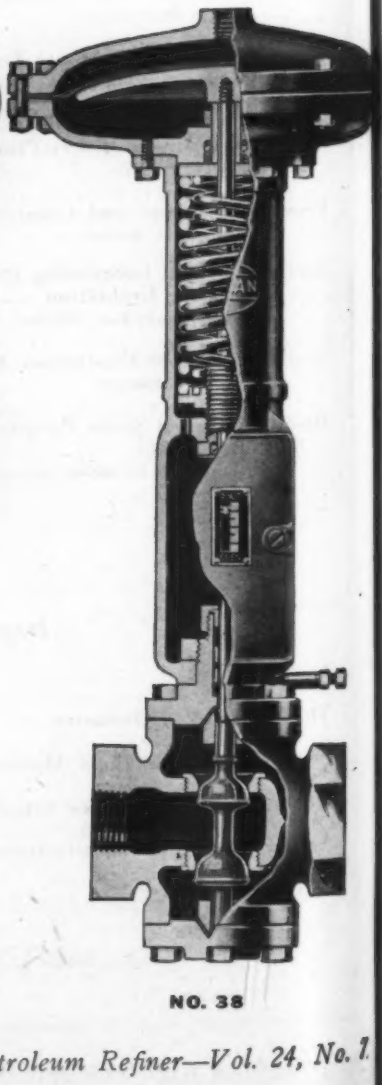

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THE LOOK BOX

Machine Failure

SOMETHING for the man of science to reflect upon is the disaster that befell the Nazi philosophy of faith in the machine. The German all was trusted to the test tube, the airplane and the tank, with men in a rear guard behind this array of physical instruments of destruction. The concentration camp was a part of the philosophy of faith in the machine.

The error of this estimate was in failure to accept the fact that man is the scientist. There can be no chemical rubber, no aviation motor fuel, no tank and no airplane until it has been fashioned mentally. When man places his own machine ahead of himself he has written a verdict of spiritual suicide. His destruction may come in the form of a superior machine of foreign design, but the assurance of its coming is in his willingness to place the machine ahead of himself.

Placing high value on the laboratory and the machine shop is understandable. Men work feverishly to build in reality what they have previously conceived mentally. In the building they forget that the mental conception came first and that it should always hold superior position. When a political regime comes to power and stakes its all on what it can build, the world is in for its round of destruction.

Thus there is a constant obligation on the man of science. He should not forget that man builds his science from mental concepts. Only by keeping his head in the stars can he hold fast to the obligation that his duty is first the making of material things for the benefit of mankind, rather than for its destruction.

Come on Over

A story of a recent conversation between Generals Eisenhower and Zhukov went the rounds of the occupation forces last week.

ZHUKOV: *"We have some German synthetic oil plants that we captured . . . We have been unable to get them operating. I understand you have some running . . . Could some of our experts come over and see . . . ?"*

EISENHOWER: *"Certainly, send them over. We will show them how to do it."*

ZHUKOV: *"You mean you do not have to ask your government?"*.

EISENHOWER: *"Of course not. Send them over."*

Zhukov was astounded and pleased. He was also unable to return the favor.

—TIME, July 2, 1945.

On the Rebound

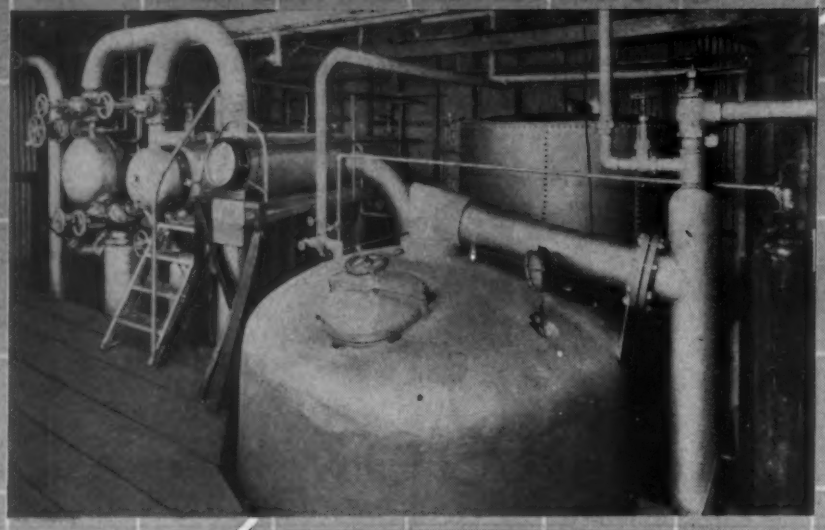
ONLY the return of unrestricted making and buying of automobiles can assure the oil industry a market for its motor fuel, come V-J day. Although automobile makers have been granted permission to make some new automobiles, the number is such that in 1946, unless restrictions are relaxed, there can be little change in private gasoline consumption.

Here are some vital auto statistics from *Tide Magazine:* Passenger car registrations are down to 25 million from the 29½ million peak. Cars are going to the junk heap at 4000 a day. One fourth of the cars now operating are 11 years old. Average age of the whole 25 million is 7 years. In prewar years the average age was 5.8 years.

Even if limited manufacture can hold the line against current junking, peacetime gasoline consumption volume can not be expected because the old car is not worthy of the sort of use demanded of new cars.

The tenacity with which owners cling to old

Dowtherm on the job!



"No Maintenance Problems . . . Fuel Consumption Amazingly Low"

Accurate and dependable temperature control in the neighborhood of 600°F. is a permanent asset of this West Coast processor since Dowtherm entered the plant. The operations manager is particularly pleased with the economy—both in maintenance and in fuel—of his Dowtherm system.

"This unit was installed in February, 1942," he writes, "and since that time it has been operating continuously in conjunction with our kettles supplying polymerized vegetable and marine oils, and other special oils to the paint, varnish, and linoleum industries.

"The fuel consumption record has been amazingly low, and because of the absence of any maintenance and repair problems we would recommend this unit without hesitation."

We quote this enthusiastic indorsement not because it is extraordinary. On the contrary, it represents the general experience of hundreds of Dowtherm users who have found safe, precise, economical heat control in a variety of different industries. A few of the positive benefits these processors receive from Dowtherm are freedom from high-pressure hazards . . . uniformity and often improvement of product . . . savings in production and maintenance time.

The Dowtherm temperature range extends to 725°F. with corresponding pressures not in excess of 110 lbs. per sq. in. gauge. If this broad scope covers your own heating process, write to Dow for full particulars.

Dowtherm

The high-temperature low-pressure heat transfer medium

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cars is the best evidence they will buy new ones. Manufacturers are anxious to provide the new cars. But the plants must be held on the beam for the war in the Pacific. Thus far WPB has granted priorities for the building of 691,018 automobiles by the end of 1946.

These cars will be sold under rationing, perhaps identical to that now prevailing. How soon this can be changed is the uppermost question. Henry P. Nelson of WPB is this hopeful:

"With luck, rationing may be lifted late this year or early next."

There are impressions in Detroit that passenger car and truck manufacturing can reach a peak of 6 million a year. The prewar peak was 4½ million, of which about 700,000 were trucks. It will require several years of record manufacturing to catch up with a four-year backlog, it having been estimated by one large car manufacturer that 18½ million cars and trucks would be required to return United States motor vehicle to normal usage.

Bombs Away

EFFECTIVENESS of bombing and the helplessness of an army that is short on motor fuel have been vividly reported by Dr. W. C. Schroeder of the United States Bureau of Mines, one of the men assigned to a technical oil mission in Germany. In his report he said:

"All of Germany's surface synthetic fuel plants, primary targets of the American Air Forces and the RAF were bombed out, shattered to bits by repeated raids. Their production, estimated at about 4,000,000 tons of oil a year at the peak, was reduced to below 5 percent of that amount despite the efforts of repair crews numbering as high as 20,000 men for a single plant. Plant production, turning sharply downward in 1943, rose only when bad weather grounded the Allied bombers.

"When reconnaissance photographs, taken at intervals after a raid, disclosed under minute scrutiny that repair workers were being taken off the job, air force officers were alerted and another strike was planned. The first jets of steam betraying that the plant was back in operation were the signal for attack and the bombers swarmed back over the target, undoing months of repair work.

"In fact the Allied bombardiers did their job so thoroughly that we learned very little from the plants themselves, but we got the information we needed elsewhere."

The following two paragraphs are from the press release concerning the findings of the investigation, participated in by American and British scientists:

"At Wesseling, site of a large hydrogenation plant, a German engineer finally admitted under questioning that he had compiled a complete story of the plant and buried the manuscript. This illustrated record of some 250 pages gave the investigators their best picture of this type of operation, disclosing one German dehydrogenation process for use in making aviation gasoline. The Americans learned that the Nazi hydrogenation plants were operated at the extremely high pressures (several hundred atmospheres) and that the discovery of new catalysts had permitted them to revise the process and convert the middle oil fractions to high-octane gasoline in a single step. By adding lead, the octane number was raised to form 90 to 95—high enough for the fuel-injection type of aircraft engine used by the Germans.

"Near Reelkirchen, an alert artillery officer noticed a German boy playing with blueprints. Suspecting their importance, he learned that these and other documents had been hidden in a farmhouse. An intensive search of this area yielded many boxes of records, which were moved into an old castle where they filled several rooms. Here, the oil mission investigators, happily undertaking the formidable task of examining the massive stacks of papers, found the answers to their final questions set forth in detail—the results through January, 1945, of German research upon the gas synthesis method of producing liquid fuels and lubricants from coal. They already had quizzed workers and examined the debris of gas synthesis plants built around 1938, but those records of Ruhr Chemie research brought the German history of this process of synthetic fuel and lubricant manufacture up to date.

" 'We had a good picture before the war of the German gas synthesis method—used primarily for producing motor gasoline, lubricating oils, and diesel fuels—but we learned of several refinements, including the use of iron catalysts and recirculating processes, as well as detailed data on the manufacture of by-products,' Dr. Schroeder stated."

From an Additive

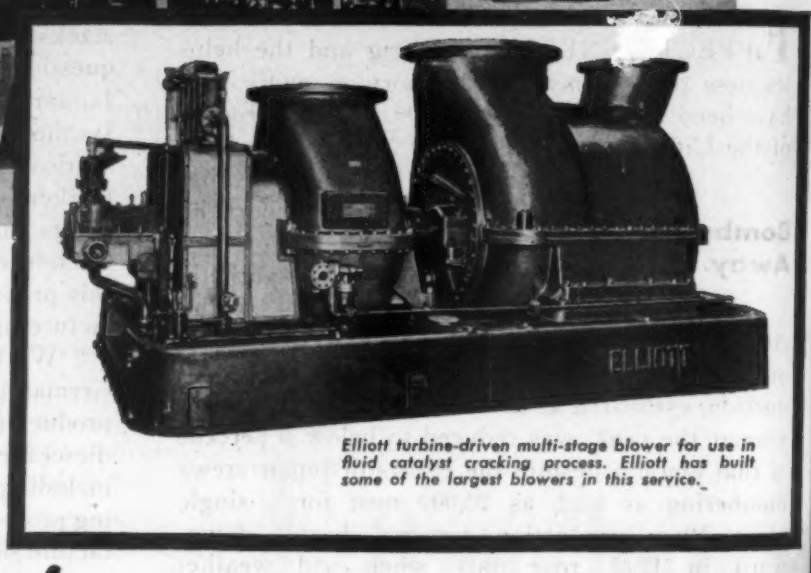
LIKE so many other discoveries Butyl rubber had its start in research of another objective. This is one of the striking points in the history of this product as given in the June, 1945, issue of *The Lamp*. While working on additives for lubricating oils, it was noted that polyisobutylene could be made heavier by increase in molecular weight, which also had a tendency to produce an effect similar to rubber.

Two chemists, R. M. Thomas and W. J. Sparks, took up the challenge of producing an elastomer from oil and had their first success when a combination of butadiene and polyisobutylene produced a product that could be vulcanized. Later isoprene replaced butadiene and improved the product.

Now Butyl rubber has won high favor as an inner-tube material and promises to win many more favors in home and industrial uses.

Catalytic cracking?

Elliott turbine-driven single-stage blowers supplying air for catalyst regeneration in T.C.C. plant—outdoor installation. Elliott has built the majority of blowers in this service.



Elliott turbine-driven multi-stage blower for use in fluid catalyst cracking process. Elliott has built some of the largest blowers in this service.

Here are the blowers for it!

Catalytic cracking requires air for catalyst regeneration and, except in small plants, this air is most economically obtained with a centrifugal blower. The blower is really the heart of a "cat cracker" and continuous operation without shut-down is all-important Many Elliott blowers are establishing outstanding records in such service. Elliott blowers are specially engineered and precision-built for the job to be done—and with modern design practices and wartime limitations, standby blower equipment is a rarity.

Consult your nearest Elliott field engineer on your next blower job. Elliott builds the driver as well as the blower, making possible a more intelligent analysis of your problem and combined responsibility for the complete machine.

P-1069

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ELLIOTT BLOWERS

Ideal for catalytic cracking

FIGURE 1. One of two testing tables, showing two valves in place and a third being set up for test. Each table accommodates four valves.

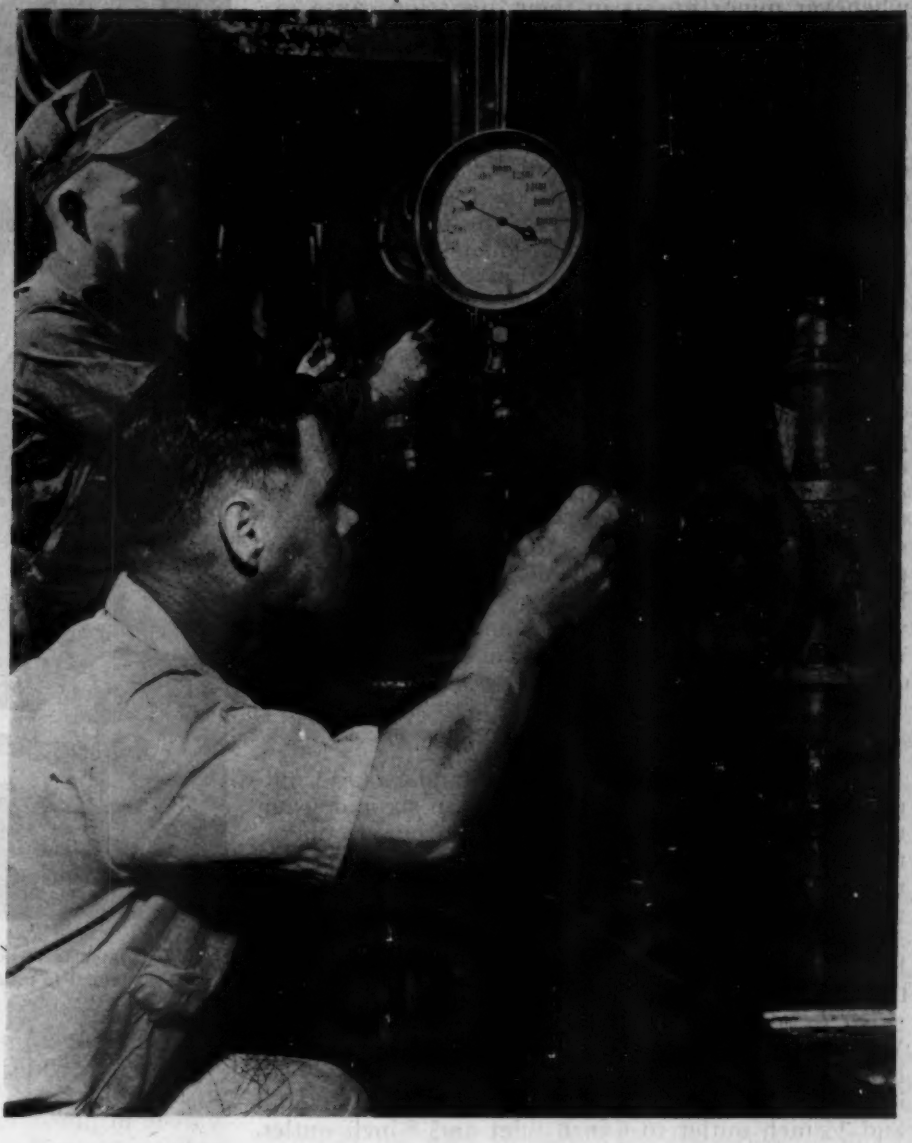


FIGURE 2. (Right) Machinist operating valves in inert-gas line applying pressure, while the inspector looks to see if the valve is leaking. Water is placed on the discharge side in this operation so that bubbles will show any leaks.

All photos with this article by B. F. Anderson.

Inspection and Maintenance of Refinery Safety Valves

E. R. WILKINSON

Chief Inspector, Standard Oil Company of New Jersey, Louisiana Division

SAFETY valves, or pressure-relief valves as they are sometimes called, are the oil refiner's assurance that his operating equipment is always protected from pressure in excess of that for which it was designed. Many people think of a safety valve as just another valve, a block of rough cast metal with a few simple machined parts. The dead-weight safety valve whose operation is dependent on a counterbalanced weight is not much more than this, but a spring-loaded safety valve is, and should be treated as, a precision instrument. The discussions in this article are associated principally with the spring-loaded type of valve. The spring-loaded valve must be fitted with accurately-machined parts and must be subjected to fine adjustments and tests if it is expected to give satisfactory and efficient operation. Accurate machining in this sense means that the surfaces must be true within tolerances of one or two thousandths of an inch and accurate adjustment must be in terms of the valve set pressure plus or minus 1 or 2 percent. The refiner can, therefore, not hope to realize the maximum degree of assurance from his safety valves unless these factors are taken into full consideration and some group in the organization is designated to inspect the valves regularly and maintain them in good working order as dictated by the inspection.

Protection of Personnel and Equipment

Properly organized inspection and maintenance of safety valves results in safe operation and thus affords protection for personnel and equipment. It thereby gives operating personnel a true feeling of security

whenever minor upsets in their operation cause excessive pressure surges on any of their equipment. If they know that their safety valves have been well serviced and maintained so that they will function when necessary, they need have no fear of any equipment failure while they are in the process of correcting the cause of any such upset in their normal operating conditions. Then too, a safety valve in good working order will relieve the pressure with a minimum loss of petroleum products. The reseating pressure should always be within 2 or 3 percent of the popping pressure. Although many valves leak after popping, even though they may have closed and reseated, it is very important that they should not hang up in an open position. This may result in excessive loss of petroleum, which may also endanger personnel and equipment if the valve is not tied into a closed blowdown system, and aside from this, may ultimately result in shutting an operating unit down, thereby causing high losses in production. A good system for servicing this equipment is therefore important, regardless of the number of valves which have to be handled. However, as the number of valves increases, the system necessarily becomes more elaborate and complex, and requires more organization and control.

Over 6000 Safety Valves

At Baton Rouge refinery of the Standard Oil Company of New Jersey, there are between six and seven thousand safety valves in almost continuous operation in many different services. The inspection and maintenance work in the shop alone requires the full time of one inspector and three or four machinists, and the part time of one welder. Many man hours besides these, of course, are required for removing the valves from their location on equipment, hauling them to and from the shop and reinstalling them. With such a large number of valves, it must no doubt be realized that many different styles and types are involved. They are used in sizes from ½-inch inlet and ½-inch outlet to 6-inch inlet and 8-inch outlet. They are used in petroleum services at popping pressures ranging from 5 to 4000 pounds per square inch, together with various combinations of temperature varying from —150° F. to +1400° F. They are used in steam services at pressures from 10 to 700 pounds with temperatures up to 750° F. Other services include air, inert gas, water, and chemicals. With this variety of operating conditions which are sometimes combined with corrosion, it has been necessary to use a large number of different metals in the design and construction of these valves. In many cases, these metals are specially-built alloys which must be impervious to the corrosive action of certain hydrocarbons and chemicals. This in itself would require a large inventory of spare parts even if all the valves had been furnished by one manufacturer. The fact that several different manufacturers are represented in this array of safety valves simply adds complication and confusion to the issue and requires an even larger stock of spare parts. Likewise, such a variety makes necessary a more elaborate shop for maintenance and requires additional skill on the part of the machine and testing operators.

Inspection

Like many other items of equipment in a refinery, the safety valves can be inspected and maintained either in place or by removing them to a central shop location. For some valves, particularly those in steam and certain water services (such as on fire pumps), it is more desirable to inspect and condition the valves in place. On the other hand, for the average valves in petroleum and chemical services, it is more desirable to have them removed and serviced in a safety-valve shop. The fundamental reasons for the difference are (1) steam valves have to be tested in place after they have been worked and reset; (2) it is very desirable to test the valves on fire pumps in place; (3) there are not usually any suitable means of testing the petroleum and chemical valves in place on the equipment; (4) as a general rule, the steam and water valves do not require as frequent machining as the petroleum and chemical valves, and (5) the ratio of petroleum and chemical to steam and water valves is very large, and the petroleum and chemical valves ordinarily require more frequent servicing. With all of these factors taken into account, it can readily be seen how a centralized safety-valve shop becomes so necessary. Furthermore, servicing the valves in a central location is conducive to more uniform handling, working of the valves, testing, setting, etc., which is very important.

FIGURE 3. Machining the seat of beveled seated disc requires a skilled machine operator to assure the proper angle within allowable tolerances.

Personnel and Equipment

A safety-valve shop cannot be expected to be any more efficient than its personnel and its valve-handling and repair facilities will permit. Insofar as the shop equipment is concerned, the basic requirements are the same for any plant, and the size of the shop is determined by the number of safety valves in

service, together with the frequency of inspection and repair. The valve-handling equipment, such as chain blocks and trolley beams and small shop trucks, are quite necessary, particularly where a large number of valves and large-size valves are involved. Valve-machining and grinding apparatus also comprise a very necessary part of the shop equipment. Testing blocks with adapter connections for various sized valves are used for subjecting the valves to required tests. The test blocks are manifolded with adequate supplies of water, oil, and air or inert gas for testing media. A small hand pump is suitable for attaining test pressures with water or oil, but a power-driven compressor is necessary for applying the air or inert gas tests. At this refinery, inert gas is used almost exclusively for the compressible testing medium since it is available at pressures up to 3500 pounds per square inch. It is essential that facilities are provided to assure that the testing media are free from any foreign matter such as scale, sand, or grit which might become lodged between the seats of a valve and thereby damage the machined surfaces when the valve closes after popping. This usually is accomplished by installation of strainers or filters, or both, in the line which supplies the testing medium.

When a valve enters the repair shop, it follows a somewhat routine pattern of processing. The accompanying photographs show a few of the many shop operations. The valve is first set up on the test bench and cleaned both on the inlet and outlet sides to remove scale or sediment prior to the initial water or oil test. It is then set in place on the test block and popped. Figure 1 shows a valve being lowered into place for this operation. The pressure at which the valve pops is recorded and if it is within 5 or 10 percent of the set pressure, it is popped two or three times more as a check to be sure that it is working properly. If these pops are clean and the valve appears to completely reseat each time, then the necessary adjustment is made to obtain a pop exactly at the pressure for which the valve is set. It is then subjected to an inert gas test to determine if the seats are absolutely tight. Figure 2 shows such a test being applied. For valves which are set at 50 pounds or less, the insert gas pressure is brought to within 3 or 4 pounds of the setting, for valves which are set in the range from 50 to 100 pounds, it is brought to within 5 pounds of the setting, and for valves with higher set pressures, this tightness test pressure is 10 percent less than the set pressure of the valve. Most of the conventional-type valves are also tested on their discharge side since many of them are subjected to back pressure in operation. This test assures that no back leakage will occur across the seating surfaces and also assures a tight valve bonnet. All tests are made with calibrated test gauges that are maintained in excellent working condition at all times. If a valve survives all these tests, it is tagged as satisfactory, sealed with the inspector's seal and provided with a metal tag by the inspector indicating the date, set pressure, location and the inspector's initials. The inspection data is recorded and the valve is returned to the operating equipment.

FIGURE 4. Special lapping rings are used for the initial grinding or lapping-in of the valve seats. Following this the disc is replaced in the valve body for a final grinding to assure perfect seating contact.

When Repairs Are Indicated

Whether or not a valve requires repairs usually is determined by the first test. When repairs are indicated, the valve is dismantled on the test block. If only grinding is necessary, this may also be done with the valve still on the test block. There are many cases, however, where nozzles or discs, or both, require machining and it is then of course necessary to remove these parts for this operation. Figure 3 shows a valve disc being machined on the small lathe which is provided as part of the regular shop equipment. When this work is required, the discs then are ground or lapped in with special lapping blocks before they are placed back in the valves. Nozzles usually are placed back in the valve bodies for the lapping-in operation. Figure 4 shows a valve disc being lapped in. Following this lapping-in operation, the disc of a valve is replaced in the valve body with the nozzle already in place, and the final fine grinding or spotting in of the seats is accomplished, thereby assuring that the nozzle and disc seating surfaces are in perfect contact with one another.

Whenever a valve is dismantled for such repairs or renewal of parts, it is thoroughly checked for proper clearances of all working parts to assure that they are within specified tolerances. When machine work has been done on either the nozzle or the disc, or both, it is also necessary to check the machined parts carefully so that their remaining thickness will not be below the allowable minimum. Reassembled valves, after completion of repair work, are properly adjusted and then subjected to the same series of tests previously outlined.

Records

The inspection and repair record of the valves is a phase of the business that is no less important than any of the repairs or testing. It is this record that determines the frequency of inspection of valves, the

INSPECTION REPORT - SAFETY VALVES

PLANT _____ SAFETY VALVE NO. _____

MAKE _____ TYPE _____ SIZE: _____ INLET: _____ OUTLET _____

MATERIAL: BODY _____ BONNET _____ DISC _____ NOZZLE _____ SPRING _____

DATE INSP.	DATE DUE	POP	REPOP	RESET	SPRING NO.	REPAIRS AND REMARKS	LOCATION

Inspection Schedule _____

FIGURE 5. This card is used for each individual safety valve in the refinery, and provides a complete history of its condition and repairs.

necessity for renewing certain parts of valves, the need for changing materials in valves, and in some cases even determines changing from one style of valve to another for a given service. It has been found that a card-record system, wherein each valve has its own complete record, is the most satisfactory. Each valve in the refinery is numbered and the cards are kept on file in numerical order. These files are maintained at the safety-valve shop for ready reference by the inspector in charge. Figure 5 illustrates the form on the cards and Figure 6 shows the inspector perusing the record of a valve to determine whether its schedule should be changed or not. From the form in Figure 5, it can be observed that each card carries permanent record data such as type of valve, size, spring number, materials, etc., space for a complete history of repairs, and a space for the inspection schedule interval.

The importance of this phase of refinery inspection and maintenance work cannot be overstressed. As in the case of any important work, there are many problems involved and the responsibilities are great. The safety of continuous operation is vitally dependent on safety valves that will work when they are needed. Good shop facilities and well-trained personnel are essential to insure the successful administration of this work.

FIGURE 6. The inspector looks over the recent past history of a valve to determine if there should be any change in the inspection schedule.

Foaming a Factor in Absorber Design

H. C. SCHUTT
Stone & Webster Engineering Corporation

THE purpose of this article is to bring forward a chemical-engineering-design problem which, although generally recognized as such, has not been subjected to an exhaustive experimental investigation and scientific analysis for the purpose of evolving a useful criterion for the guidance of chemical engineers in designing absorbers and fractionators. The problem concerns the handling of liquids susceptible to foaming in conventional absorption or fractionation equipment. Data are presented showing the foam-forming tendency of various gasoils which may be used as absorption media, and the effect of the foam layer upon the performance of an absorber. Suggestions are made for a systematic investigation of the subject to develop a design criterion to be applied in the rating and design of absorbers and fractionators.

THE problem of foam prevention is receiving at present a great deal of attention in the automotive and machine industry after it was recognized that foaming of industrial lubricating and cooling oils endangered their effectiveness and consequently the functioning or performance of automotive engines, steam turbines and other power-producing and transmitting machinery. Realizing the extreme importance of operating reliability of all equipment in the service of the armed forces, especially that of engines powering airplanes and tanks, the Army Ordnance Department early in 1943 urged CRC to investigate the subject. The Coordinating Lubricating Research Committee, CLR, a subcommittee of CRC, is studying the problem and has recently reported on its work.[1] Perusal of these reports motivated this article, which is primarily intended to stimulate research work on foaming as it concerns the processing industry and affects the design and performance of certain important apparatus or unit operations. Absorption is one of these and forms the specific subject of this discussion.

Types of Absorption Systems

Absorption is widely practiced in petroleum refining for extracting from gases all constituents useful for the manufacture of motor fuel or basic compounds for chemical synthesis. There are essentially two different types of absorption systems in application in the industry. The first and original method, illustrated in Figure 1, is characterized by the use of a special absorption menstruum, usually a kerosine or a light gasoil having boiling range sufficiently above the boiling point of the heaviest constituent to be absorbed so that it may be readily and completely stripped of the absorbed hydrocarbons in the still. The absorption oil may be selected as to boiling range, paraffinicity, emulsification and foaming tendencies to insure satisfactory performance of the equipment. The California Natural Gasoline Association has established specifications and testing procedure for the evaluation of absorption oils to guide process engineers and operators.[2]

The second method, which is illustrated in Figure 2, comprises a self-contained process in which a special fraction of the material charged is recycled as absorbent. This process usually is applied where

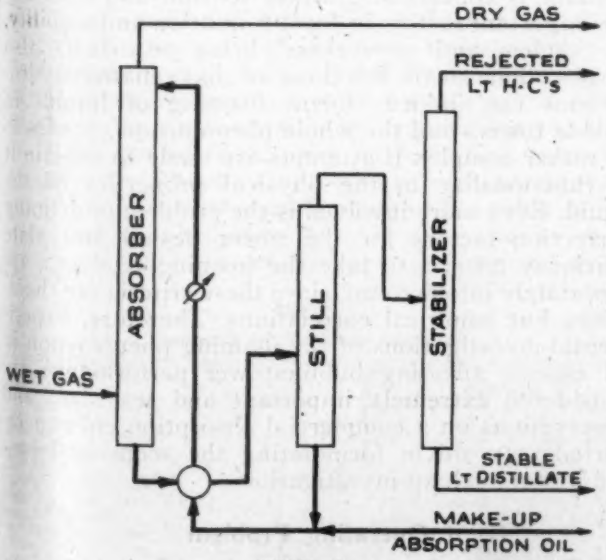


FIGURE 1
Conventional absorption system using extraneous medium

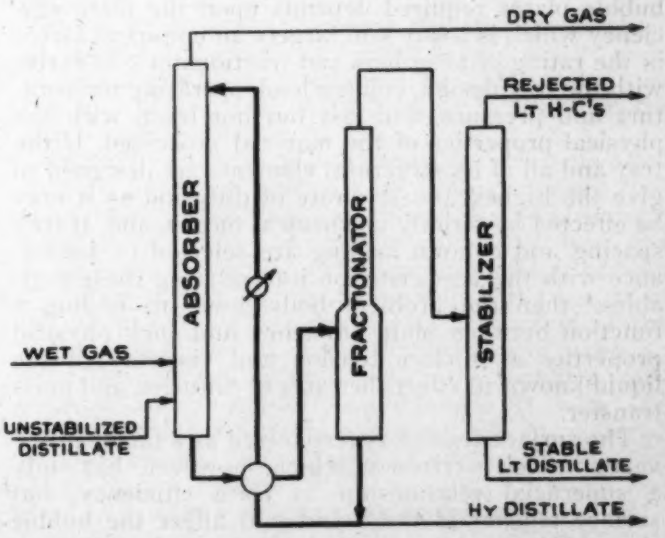


FIGURE 2
Self-containing absorption system using indigenous distillate fraction

separation of a light and heavy distillate is required for subsequent processing, or a suitable absorption oil is not readily available. Figure 3 represents another case of a self-contained absorption recovery method which uses a gasoil-boiling-range fraction from the composite hydrocarbon stream processed. This system has frequently been applied in thermal

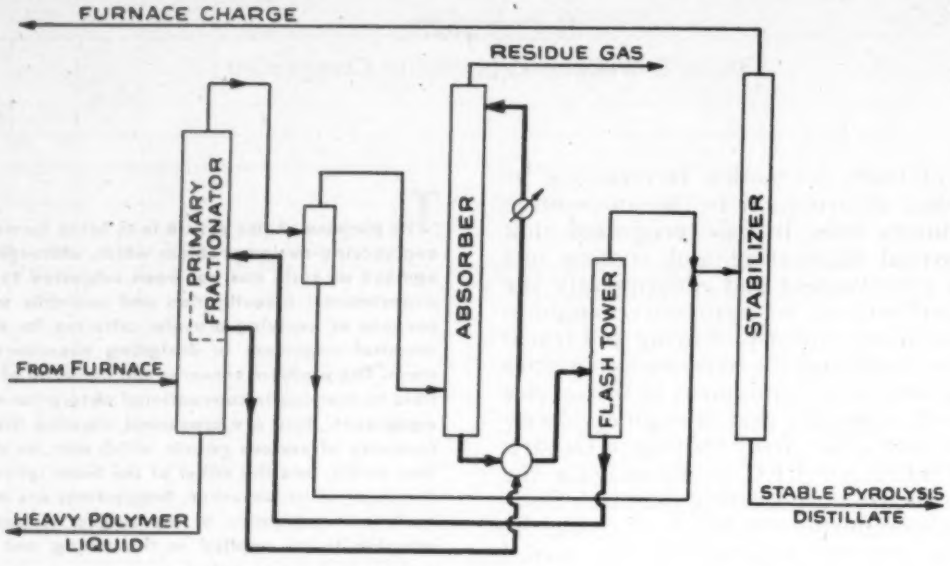


FIGURE 3
Self-Contained absorption system using indigenous gasoil fraction

cracking units and corresponds to the flow used in the pyrolysis unit to which this article has specific reference. It is evident that in case of a self-contained absorption system as illustrated by Figures 2 and 3, there is no control over the quality of the absorption medium and in the design of the absorber such factors as the emulsification and foaming tendencies of the absorbent must be taken into consideration.

Absorber Design Factors

Absorbers generally are designed following the procedure developed by Kremser and known as the "Absorption Factor Method."[3] The number of theoretical plates or contact stages necessary may be determined by this method, but the actual number of bubble plates required depends upon the plate efficiency which is today still largely an empirical factor in the rating of absorbers and fractionators. It varies with the tray design, column load, operating temperature and pressure, and last but not least, with the physical properties of the material processed. If the tray and all of its structural elements are designed to give the highest possible rate of diffusion as it may be effected by strictly mechanical means, and, if tray spacing and column loading are selected in accordance with the best criterion interrelating these variables,[4] then the problem boils down to finding a function between plate efficiency and such physical properties as surface tension and viscosity of the liquid known to affect the rates of diffusion and mass transfer.

The surface tension is recognized as a factor in the vapor velocity criterion which, however, has only a superficial relationship to plate efficiency, but surface tension of the liquid will affect the bubble size of the vapor or gas and consequently the interfacial contact and diffusion per contact stage which in turn governs the plate efficiency.

Viscosity long has been recognized as influencing diffusional or mass transfer processes as expressed by the Stokes-Einstein equation for molecular diffusivity and Chilton and Colburn[5] mass transfer equation. Inspired by these fundamental concepts, Drickamer and Bradford[6] have established a correlation between liquid viscosity and tray efficiency from actual tower performance data embracing absorbers, as well as all types of fractionators encountered in a modern oil refinery. This correlation seems to be quite satisfactory as far as the data from a single plant are concerned but values derived from published information show in numerous cases rather large deviations from the function obtained by means of interpolation. Variations in tower design and loading may be the reason for this but it may also be attributed to special characteristics of the liquids, such as their foaming tendency.

The foam-forming quality and foam stability, which may vary widely for different liquids, have not been subjected to an exhaustive study as far as their effect upon the performance of an absorber or fractionator is concerned. Surface tension and viscosity are important factors in foam formation and stability, as Souders and co-workers[7] bring out. It is also known that small fractions of oxygenated hydrocarbons can induce violent foaming of liquids in bubble towers and the whole phenomenon appears to be rather complex if attempts are made to explain it in functionality to the physical properties of the liquid. Even more involved is the problem of defining correction factors for the tower design and plate efficiency criteria to take the foaming tendency appropriately into account, since these criteria are themselves but empirical correlations. Therefore, experimental investigations of the foaming phenomenon in all aspects affecting bubble-tower performance are considered extremely important and test data and observations on a commercial absorption column reported may aid in formulating the scope and procedure for such an investigation.

Operating Problem

Difficulties with an absorber developed during the initial operation, early in 1938, of a pyrolysis unit

TABLE 1
Analysis of Oils Tested

	Pyrolysis (Synthetic) Gasoil	Therm. Cracked Gasoil	Straight Run Light Gasoil	Absorption Oil (Light Gasoil)
Gravity at 60°/60° F.:				
Degrees, A.P.I.	30.2	33.4	41.1	43.8
Specific	0.875	0.858	0.820	0.807
A.S.T.M. Distillation:				
I. B. P., °F	216	413	406	386
10 percent	401	446	430	412
20 percent	413	471	437	422
30 percent	422	480	445	432
40 percent	430	507	453	441
50 percent	435	530	462	450
60 percent	442	554	470	458
70 percent	451	583	478	466
80 percent	467	615	488	477
90 percent	507	651	504	496
End Point	572	....	540	536
Recovery, percent	98.0	....	98.0	97.0
Residue	1.0	....	1.0	1.0
Loss	1.0	....	1.0	2.0
Distilled at 662° F., percent	....	93	....	....
Charact. Factor (UOP)	11.05	11.63	11.87	12.02

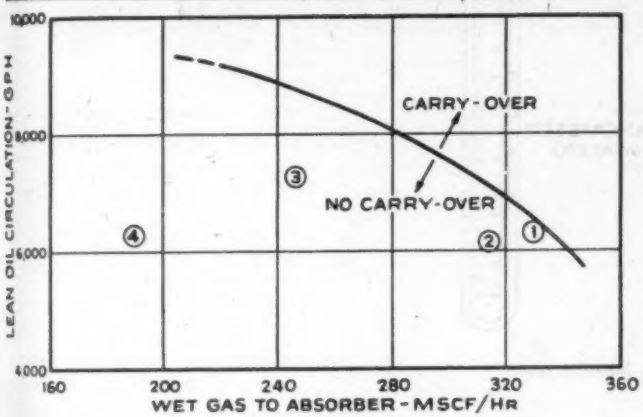


FIGURE 4
Critical absorber load (18-inch tray spacing)
⊖ Loading during tests (18- and 36-inch tray spacing)

producing an aromatic-type distillate from a mixture of propane and butane. The absorber formed a vital unit in the system separating the conversion products as shown in Figure 3 and was designed to recover at least 80 percent of the propane-propylene fraction of the inlet gas. The absorbing menstruum was a gasoil-boiling range distillate fraction, also a pyrolysis product, an inspection of which is given in Table 1. Definite limitations in the gas-handling capacity as well as the oil-circulation rate were apparent from the start and seemed to increase as the liquid produced became more aromatic. Although the foam-forming tendency of the absorbent was recognized as being mainly responsible for the poor performance of the absorber, alterations were made in the equipment for the purpose of increasing the tray spacing and the liquid down-flow capacity, but design capacity flow could not be obtained without excessive liquid carry-over or even flooding of the column. The vapor loading seemed to be more critical with respect to the carry-over point, and tests were made to determine the flow rates at which liquid entrainment in the residue gas would appear at the slightest increase in gas flow. This carry-over criterion is given in Figure 4. With the knowledge of the critical flow rates, test conditions at which the absorber would safely function in a normal way could then be established and performance data obtained to determine the plate efficiency. Since the gas-flow rate was held to be governing the height of the foam layer, tests were made at various gas loads with only relatively small variations in lean-oil circulation. The plate efficiencies were determined by using Kremser's absorption factor concept in conjunction with the key constituents, i.e., propylene and propane. A summary of the absorber operating conditions and calculated plate efficiencies is given in Table 2. The variation of the tray efficiency with the vapor load or superficial gas velocity is graphically shown in Figure 5.

TABLE 2
Summary of Absorber Test Data

	Units	TEST NO. 1	2	3	4
Absorber Diameter	Inches	54	54	54	54
Tray Spacing	Inches	18	36	36	18
Operating Pressure	Psi Gage	245	245	245	245
Operating Temp., Lean-Rich Oil	°F.	76–81	82–85	70–84	76–82
Lean Oil Circulation	GPH	6,320	6,100	7,200	6,250
Superficial Gas Velocity (Based on Wet Gas Flow)	Ft/Sec.	0.352	0.34	0.26	0.20
Plate Efficiency	Percent	16.7	18.7	28.0	31.2

It should be mentioned that the value of the absorption factor, being defined as $\frac{L}{G} \times \frac{1}{K}$, is a function of the equilibrium constant, which in turn will vary quite markedly with the characteristics of the lean-oil solvent as shown by Kirkbride and Bertetti.[8] The constants used in establishing the absorption factor correspond to a naphthenic type gasoil, having a characterization factor (UOP) of 11.5 to 11.6 as compared with 11.1 indicated for the absorption medium under test. Therefore, the efficiencies given in Table 2 and shown in Figure 5 may not be quite in the right order of magnitude, but the trend is correct and gives a true picture of the variation in the absorber performance.

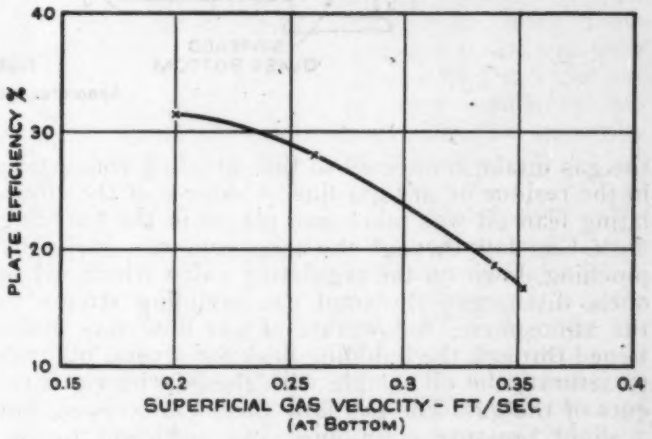


FIGURE 5
Plate efficiency vs. vapor load

Since the absorber was operated far below its rated capacity, based on generally used design criteria, and since viscosity and surface tension of the absorbent must have been essentially the same for all tests, the large variations in plate efficiency may be attributed primarily to the degree of foaming or the height of the foam layer, which in turn is a function of the vapor or gas load. It seemed therefore of value to have some specific information on the foaming tendency of the absorbent and compare it with the response of other light gasoils which are encountered in refineries and may be used as absorption oil.

Test Apparatus and Procedure

Figure 6 shows the assembly of the laboratory apparatus in which the foaming tests were executed. It consisted of an accurately-calibrated orifice, a flow-

indicating manometer for measuring the gas feed rate and a bubbling flask having a sintered glass arch in the bottom for even dispersion of the gas in the liquid. A metric scale attached to the outside of the flask permitted the notation of liquid and foam levels in the flask.

The test procedure was briefly as follows: The apparatus assembly was set up at the absorber and the gas intake connected to the sampling connection in the residue or dry gas line. A sample of the circulating lean oil was taken and placed in the bubbling flask. Gas flow through the apparatus was started by pinching down on the regulating valve which, when open, discharged the total gas sampling stream to the atmosphere. A low rate of gas flow was maintained through the bubbling flask for several minutes to saturate the oil sample with the heavier constituents of the gas. The gas flow then was stopped, but a slight pressure maintained just sufficient to displace the liquid below the sintered glass arch, and then the height of the foam-free liquid level above the apex of the sintered glass ascertained. The actual foaming experiments then were performed by establishing various rates of flow and measuring the height of the foam layer as the differential between the liquid-foam interface and the top level of the foam layer. Attempts were made to ascertain experimentally the density of the foam by determining the velocity of the gas bubbles through the liquid layer from which the apparent specific gravity of the dense phase liquid-gas mixture could be calculated. By measuring the height of the liquid level during the bubbling period, the weight of the dense-phase liquid was obtained which, when subtracted from the weight similarly calculated from the observed static height of the liquid column, gave the incremental liquid quantity in foam suspension. After two or three readings of foam and dense-phase liquid level the flow was stopped and the time it took for the foam to collapse measured with a stop watch. Total time of foam break-up was taken as the time elapsing from cessation of flow until a clear liquid surface appeared, excepting a ring of bubbles at the periphery partly adhering to the wall of the flask. The rate of foam collapse was determined by observing the time required for the foam to recede from its maximum or test height to within 2 or 3 mm of the liquid level. As a further attempt to obtain a value for the foam density, the rise in the liquid level was observed from the instant the gas flow was stopped to the moment of total foam collapse. It should be mentioned that the foam-density determinations were far from precise, as the experimental apparatus lacked the refinements necessary for making accurate measurements of short-time incremental changes.

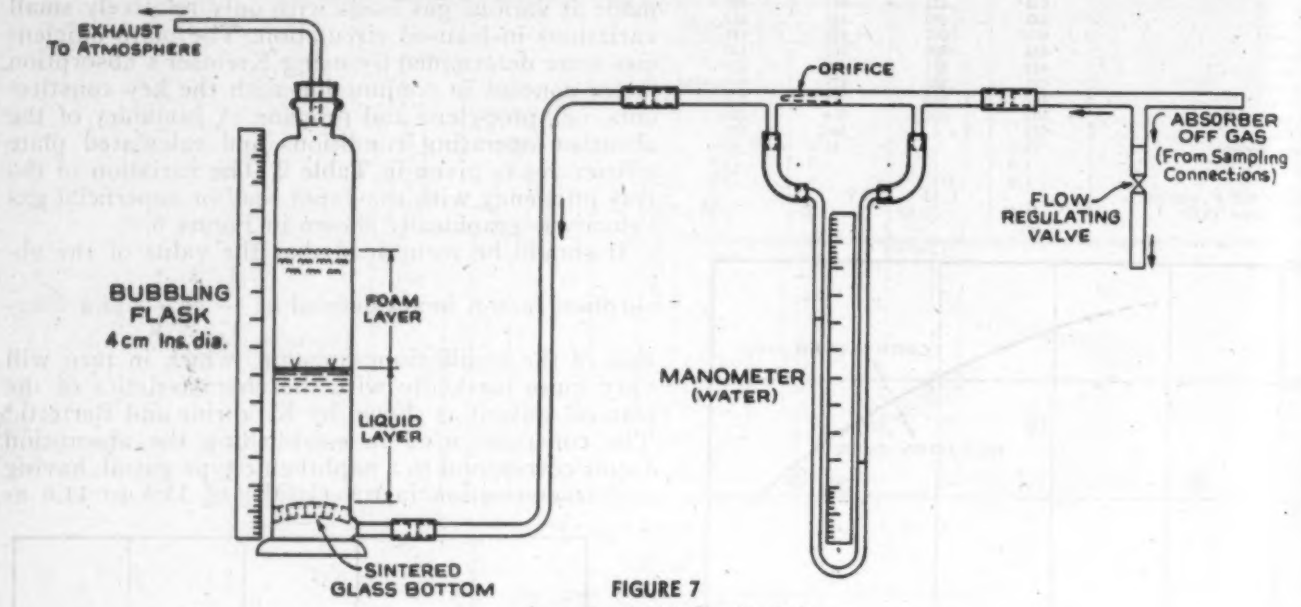


FIGURE 7
Apparatus used in foaming tests

The foam density appears to be considerably higher for the pyrolysis or low paraffinicity gasoil than for the normal absorption oil having a characterization factor of around 12.0. The apparent densities are in the order of 0.05 to 0.08 gr/cc for the former and 0.02 to 0.04 gr/cc for the latter, which indicates that approximately twice the amount of oil is held in foam suspension in the case of the synthetic or pyrolysis gasoil for a given height as compared with a normal light absorption oil.

Test Data and Their Significance

The gas used in all foaming tests had the following properties:

Specific gravity (air = 1.0) (By Edwards balance)	0.767
Unsaturates, Vol. percent (By bromine absorption)	14.2
Composition:	
H_2	6.1 mol percent
CH_4	58.2 mol percent
C_2H_4	8.0 mol percent
C_2H_6	16.5 mol percent
C_3H_6	5.6 mol percent
C_3H_8	5.0 mol percent
C_4+	0.6 mol percent

The inspections of the different oil samples tested are contained in Table 1 covering a wide range of paraffinicity. The actual foaming test data are given in Table 3. It will be noted that the gas flow governs the height of the foam layer while the initial height of the liquid level has only a minor influence. The time for total collapse of the foam as well as the rate of collapse appear to be functions of the physical properties of the liquid. Unfortunately, no viscosity nor surface tension determinations were made on the

TABLE 3
Test Data and Observations

OIL UNDER TEST	Oil Density At Test Temperature (75° F.) gr/cc	Height of Oil Above Sintered Glass Bottom* (No Gas Flow) mm	Gas Flow Liters/min.	FOAM LAYER Height mm	FOAM LAYER Volume cc	FOAM COLLAPSE Time Down to 2-3 mm Layer sec	FOAM COLLAPSE Time for Total† sec	FOAM COLLAPSE Rate‡ cc/sec
Pyrolysis Gasoil	0.868	107	0.56	20	25.1	....	60+	....
		110	0.81	22	27.7	24.0	60+	1.0
		107	0.83	26	32.7		60+	
		107	1.10	33	41.5		60+	
		110	1.10	30	37.7		60+	
		107	1.26	39	49.0		60+	
		88	1.17	32	40.2	45.0	60+	0.8
		115	1.17	35	44.0		60+	
Therm. Crack. Gasoil	0.851	84	0.85	25	31.4	15.0	18	1.9
		84	1.17	40	50.2		16	
		110	1.17	42	52.7		18	
Straight-Run Light Gasoil	0.813	81	1.17	14	17.6		10	
Absorption Oil (Light Gasoil)	0.800	90	0.62	6	7.5		7	
		85	1.00	9	11.3	3.0	7	2.7
		85	1.20	12	15.0		8	

* Height measured above the apex of the sintered glass arch. † Total foam disappearance except the bubbles on the periphery of the liquid surface adhering to wall of flask.
‡ Rate was not uniform over period.

oil samples tested, nor was any analysis made of the constituencies revealing the type of hydrocarbons as well as acidic and other impurities contained in the samples. The relative foam stability and its high apparent density for the pyrolysis or synthetic gasoil are of special significance with respect to the liquid handling capacity of a tower, and explain the occurrence of column flooding at relatively low liquid loading. The height of the foam layer would affect the plate-to-plate liquid entrainment and therefore the efficiency.

An absorber which has to handle an absorbent susceptible to foaming should be designed with wide tray spacings and for relatively low superficial vapor velocity. The exact allowances which have to be made will depend upon the specific foaming tendency of the menstruum.

Foam Suppressing Agents

Foam-inhibiting chemicals have been used in some installations of a self-contained absorption system where serious operating trouble and loss in production capacity developed from foaming. Effective foam-suppressing agents are higher alcohols such as caprylic and octyl alcohol, hydroxylamines, esters and ethers. It appears, however, that the continuous use of such chemicals is a costly operating expedient and to be avoided if possible.

Strong foaming tendency also may be exhibited by chemical absorbents used for the recovery of butadiene, isoprene, isobutylene from hydrocarbon mixtures, or for the extraction of sulphur compounds from gases and distillates. Foam-inhibiting agents frequently are employed with these solvents to extend their service life, and the use of such additives has proved to be generally economical.

Conclusion

The foaming of liquids represents a major problem in industrial process design. The specific operating and test data given in this article indicate the importance of the proper selection of the absorbent for an absorption recovery cycle applied as an integral process step of modern refining operations. If an indigenous menstruum is used, information on its foaming characteristics should be obtained so that proper design allowances can be made. A thorough investigation of the foaming phenomenon as it concerns the refining industry seems highly desirable. The experimental data presented in this article are insufficient for an exhaustive analytical study and mainly intended to define the problem and suggest ways and means for its practical solution.

LITERATURE REFERENCE

[1] Ambrose & Trautman. Paper presented at SAE meeting in Detroit, Jan. 8-12, 1945.
[2] California Natural Gasoline Association; Bulletin S-343; 1934.
[3] Kremser, Proc. California Natural Gasoline Association. 5; 2; 1930.
[4] Souders & Brown. Refiner & Nat. Gas. Mfr. 13; 32; 1934.
[5] Chilton & Colburn. Ind. Eng. Chem. 26; 1183; 1934.
[6] Drickamer & Bradford. Nat. Pet. News. 35; R378; 1943.
[7] Souders, Huntington, Cornell, Emmert. Ind. Eng. Chem. 30; 89; 1938.
[8] Kirkbride & Bertetti. Ind. Eng. Chem. 35; 1242; 1943.

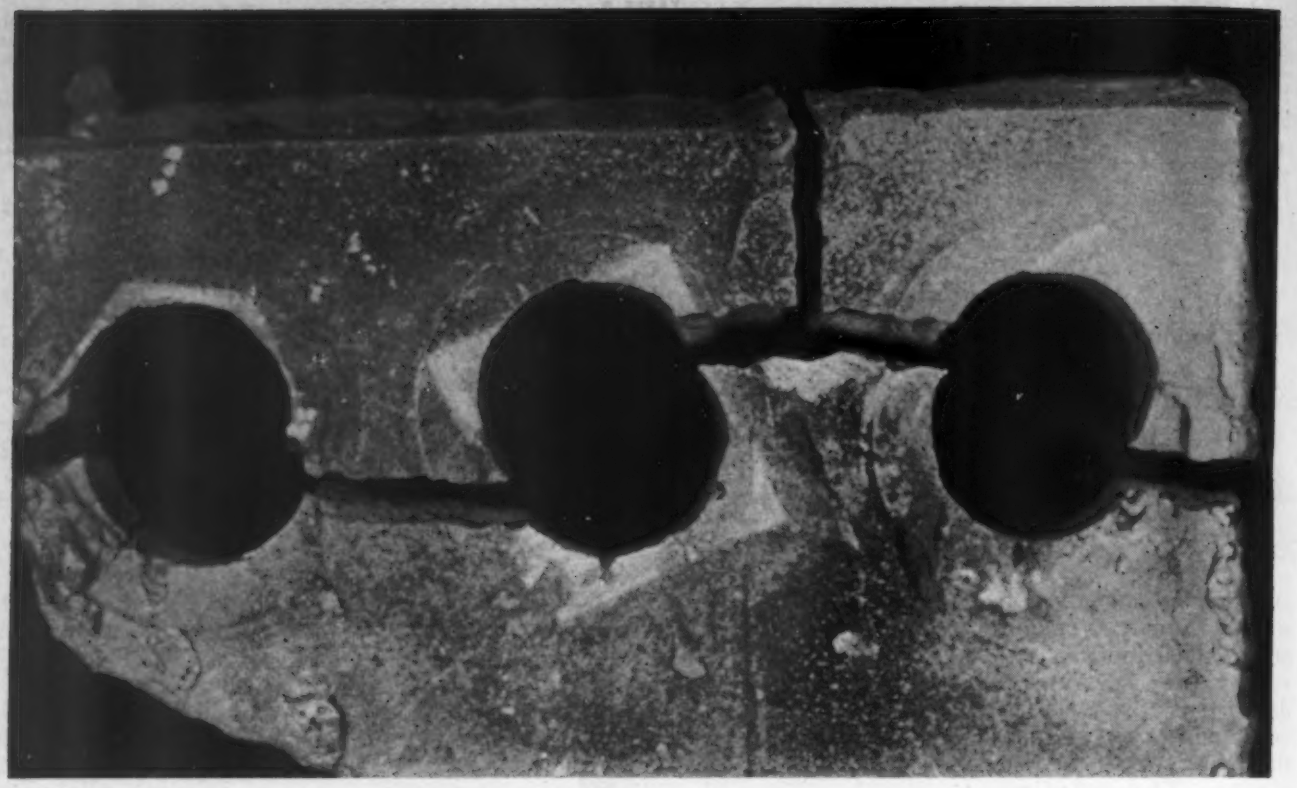


FIGURE 1. Damage caused by intercrystalline cracking.

Preventing Boiler Metal Embrittlement

By JOHN DREW BETZ, Chemical Engineer, W. H. and L. D. BETZ, Philadelphia

BOILER-METAL embrittlement (more correctly termed intercrystalline cracking) is a potential source of danger in all steam-generating plants. While many technical articles have been presented on the subject of embrittlement, most of these deal with the research and laboratory data on which our present knowledge of embrittlement is based. The purpose of this paper is to briefly outline the present status of the embrittlement problem in so far as it affects the practical operation of a power plant.

There is as yet no complete agreement on the basic theoretical physical and chemical causes for the phenomenon of embrittlement. Investigators also are not in complete agreement as to the solution to the problem. Some investigators believe the best solution to the embrittlement problem to be in the production of different types of steel for boiler metal. Other investigators indicate the solution to be in the correction of boiler-water characteristics. While use of special steel for boiler construction is theoretically a good answer to the problem, it is also a long-range proposition and therefore the correction of the boiler-water characteristics is of more practical significance in preventing embrittlement in boilers which are now being designed as well as those which are in operation. This article is concerned with the prevention of embrittlement by correction of boiler-water characteristics.

RESEARCH now has provided means for overcoming the embrittling characteristics of a boiler water. Although it is not necessary for the power-plant operator to be completely familiar with all the details of the various investigations made on the subject of embrittlement, he should have a working knowledge of the manner in which embrittlement may effect his plant as well as the means available to investigate and eliminate this danger.

Causes of Embrittlement

There are three factors which must exist simultaneously to produce embrittlement of boiler metal.

1. Leakage of the boiler water must take place so as to permit escape of steam and concentration of the boiler water at the point of leakage.
2. The boiler metal must be subjected to stress—either internal resulting from cold working of the metal, or external due to expansion and contraction.
3. The concentrated boiler water at the point of leakage must possess embrittling characteristics, and chemically attack the boiler metal.

The first two factors of leakage and stress primarily occur at riveted seams, blow-off flanges, and

at rolled-in tube ends. Modern welded boiler construction has eliminated riveted seams as areas especially prone to embrittlement, but the danger of embrittlement still exists at rolled-in tube ends. Leakage of the boiler water from the rolled-in tube ends can produce the required concentration of boiler water.

Intercrystalline cracks are entirely different from the cracks produced by ordinary steel failure. These intercrystalline cracks actually pass around the grains of the metal instead of going right through the grains. Investigators have shown that intercrystalline cracking is not produced at normal boiler-water concentrations, but that evaporation at the point of leakage will build up local concentrations of sodium hydroxide to the range of 75,000 to 500,000 parts per million. Thus, at rolled-in tube ends there may exist simultaneously the three factors necessary for embrittlement—leakage, stress, and concentration of a boiler water with embrittling characteristics. However, it has been definitely proved that if any one of these factors is absent, embrittlement cannot occur.

Since very little can be done to prevent leakage and stress in power-plant operation, the answer to the embrittlement problem is in rendering the water non-embrittling by use of inhibitors. If the boiler water is naturally non-embrittling or has been made non-embrittling by the addition of specific inhibitors, the other factors of leakage and stress can be neglected. Conversely, should it be shown that a boiler water does possess embrittling characteristics, the possibility for embrittlement is always present should the additional factors of leakage and stress occur. Therefore, it is imperative that all boiler waters be investigated for embrittling characteristics. If the boiler water is found to be embrittling, steps should be taken to render it non-embrittling and thus remove the "Sword of Damocles" that hangs over the power plant operation.

Detection of Embrittling Characteristics

Unfortunately, with our present knowledge of embrittlement, it is not possible to definitely determine whether or not a boiler water is embrittling by means of chemical analyses of the water alone. Should this be possible, the advantages of this simple method would be numerous. However, it is quite possible that with more experience some standards can be established. At the present stage of investigations of embrittlement, there has not been sufficient information accumulated for the establishment of a positive universal standard.

Early investigations of embrittlement indicated that sodium sulfate possessed the ability to render a boiler water non-embrittling and the A.S.M.E. sulfate-carbonate ratios were established as a result of these early investigations. This ratio was determined by dividing the sodium sulfate content of the boiler water by the sodium carbonate content. The American Society of Mechanical Engineers suggested the following ratio be maintained:

Up to 150 lb. gage, ratio of 1
150 to 250 lb. gage, ratio of 2
Above 250 lb. gage, ratio of 3

If the ratio obtained from the boiler-water analyses was equal to or higher than that shown above, it was thought that the water should not cause intercrystalline cracking. If a lower ratio was obtained it was necessary to feed sodium sulfate or sodium acid sulfate to the boiler water in order to raise the ratio. Later work and additional experience proved that the maintenance of these ratios in a boiler water did not necessarily prevent embrittlement. These ratios served merely to "fill a gap" and are no longer considered protection against embrittlement. In our own investigations we have found many boiler waters of embrittling characteristics, even though the A.S.M.E. ratios were maintained. No authoritative ratio has as yet been devised to replace the A.S.M.E. sulfate-carbonate ratio and consequently no authoritative prediction of embrittling tendencies of a boiler water can be based on the chemical analyses of the water alone.

Within the last few years a direct embrittlement test has been developed which will indicate whether a boiler water has embrittling characteristics. It consists of placing a steel specimen in contact with the boiler water under extreme concentrations and simultaneously placing the steel specimen under a condition of severe stress. In other words, this embrittlement test is literally an "embrittlement pilot plant" in which the embrittlement is accelerated so that an answer can be obtained in a relatively short time.

There are two basic methods of conducting this embrittlement test—one can be conducted in a laboratory; the other is conducted in the power plant itself. If the test is to be conducted in a laboratory, a gallon sample of boiler water is secured and forwarded to the laboratory. There it is subjected to pressure in laboratory bombs and under concentration is in contact with a steel specimen. This test is continued for a period of from 30 to 90 days at

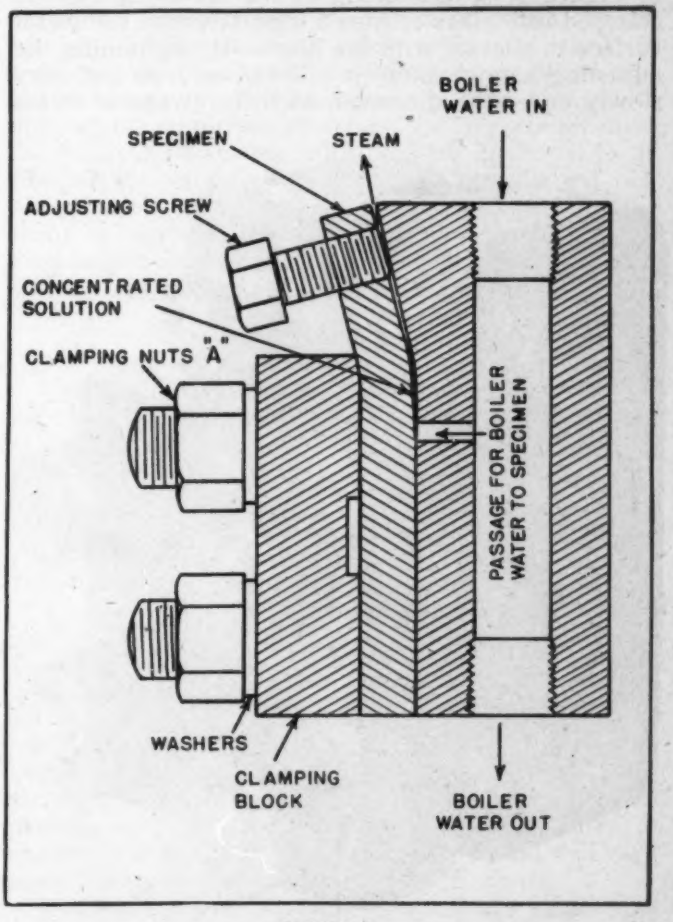


FIGURE 2
Cross-sectional drawing of embrittlement detector.

which time the specimen is removed and examined for intercrystalline cracks. While this laboratory testing for embrittlement is convenient and simple in so far as the power plant is concerned (all that is required of the power plant is the collecting of the sample), this procedure can be recommended only very rarely for the specific reason that the test is made with a "spot" sample and will only indicate whether or not the boiler water possessed embrittling characteristics at the time the sample was collected. If water characteristics change due to fluctuation in the raw water or chemical treatment it is possible for the embrittling characteristics of the boiler water to change.

The most authoritative method of embrittlement testing is conducted in the power plant itself, employing the embrittlement detector as developed by the United States Bureau of Mines. A cross-sectional drawing of this test unit is shown in Figure 2. It consists of a rectangular block 5 inches long, 3½ inches wide and 2¼ inches thick with a ¾-inch hole bored in it, through which the boiler water circulates to keep the entire unit at approximately boiler water temperature. The test specimen, a steel bar 5 inches long, ¾-inch wide and ½-inch thick is bolted into a slot in this block by a clamping plate and four studs. The test bar, clamping plate, and studs are illustrated in Figure 3. The bending of the specimen as it is clamped into place creates a high stress in the metal surface in contact with the block. By tightening the adjusting screw, water is allowed to leak out very slowly under the specimen, with the escape of steam

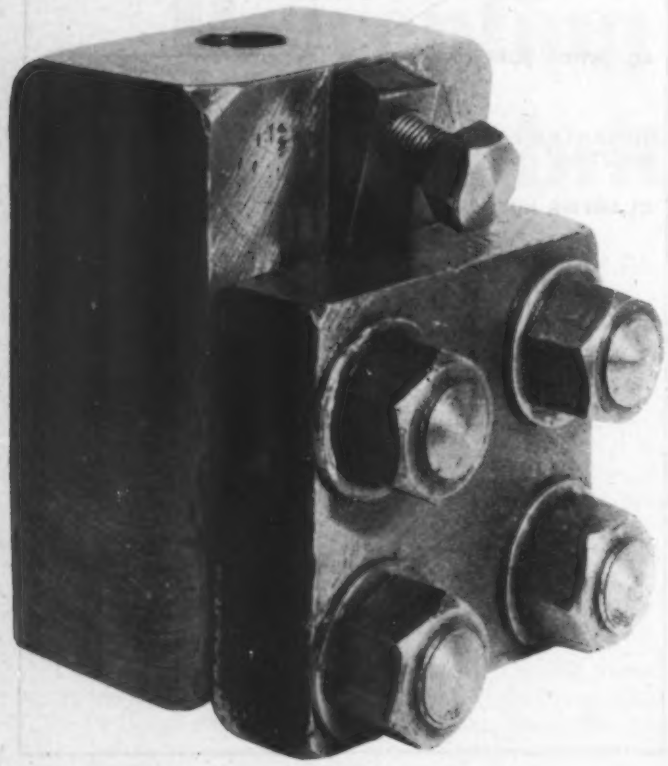


FIGURE 3
The embrittlement detector.

leaving a concentrated solution in contact with the stressed surface. Thus, again referring to the three factors necessary for embrittlement, the embrittlement detector produces the conditions of leakage and stress. If the concentrated boiler water possesses embrittling characteristics the test bar will develop intercrystalline cracks within 90 days, and in cases of severe embrittling characteristics the bar will crack within 30 days. Occasionally, the specimen will show definite cracking on its removal from the block, although in many instances the cracking is revealed only upon further bending in the course of

FIGURE 4
Detector specimen bar.

subsequent examination of the specimen bar in the laboratory of the supervising organization.

The embrittlement detector is most conveniently installed in the continuous blow-down line of a boiler. If continuous blow down is not installed, boiler water may be taken off at any convenient point and either returned to the boiler or run to waste. Although the embrittlement detector requires adjustment once per day, it possesses the advantage of operation for a period of 30 to 90 days under the actual conditions to which the boiler metal is subjected. Thus, the Embrittlement Detector takes into account fluctuations in water characteristics during the period of the test. In addition, boiler-water samples are obtained during the beginning, middle and end of the test run and analyses of these samples are correlated with the results obtained from the test specimen.

Figure 4 illustrates the appearance of three test specimens representing successive tests at a plant operating at 300 psi. The test bar in the foreground cracked badly after a 30-day exposure to the boiler water. The middle test specimen is a confirming test. While this bar is not completely cracked in half, it does exhibit numerous intercrystalline cracks which become apparent under a low power microscope. The third and last test bar, which has been further bent in the laboratory, shows absolutely no cracking and is the result of a test run employing a chemical inhibitor for the correction of embrittling characteristics of the boiler water.

Chemical Treatment Methods

There are two general methods for preventing embrittlement by the treatment of boiler water. One method is termed coordinated pH-phosphate control and involves the simultaneous control of both pH and phosphate content of a boiler water, so that no "free" sodium hydroxide is present. Unfortunately, this method has a very limited application. The second method for the prevention of embrittlement, and the one which is more universally employed, is the use of chemical inhibitors. At this time, it is still impossible to predict which of several chemical inhibitors will prove most satisfactory and each one must be tried, one after the other, until one is found that will render the water non-embrittling. While

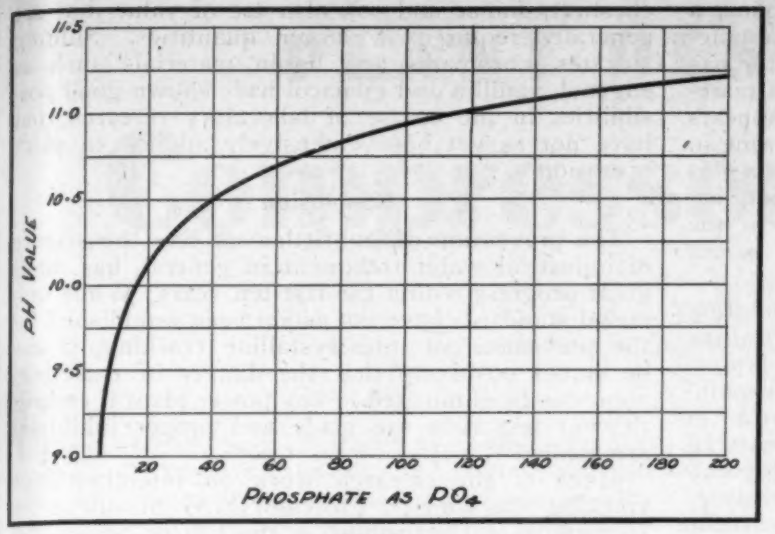


FIGURE 5
Approximate pH values of trisodium phosphate solutions.

sufficient information and data have not been accumulated to absolutely predict the correct chemical inhibitor on the first test run, research data do generally indicate the inhibitor most likely to be successful under any particular set of operating conditions.

Coordinated pH-Phosphate Control

Some early investigations seemed to indicate that the phosphate ion possessed the property of rendering the boiler water non-embrittling. Later research proved that the phosphate ion will neither cause nor prevent intercrystalline cracking and is of no value in the prevention of embrittlement. However, a newer idea involving the control of both pH and phosphate has been developed and if this coordinated pH-phosphate control can be established, embrittlement will be prevented. This method of cordinated pH phosphate control involves the simultaneous control of both the pH and phosphate content of a boiler water in such a way that the pH value of the boiler water is never higher than the corresponding pH value of a trisodium phosphate solution of the same PO_4 content.

It has been established that sodium hydroxide is the prime offender in creating a water of embrittling tendencies. If a boiler water contained no sodium hydroxide it could be expected that the water would be non-embrittling. However, in normal water-conditioning control caustic soda may be added to a boiler water to elevate the pH in order to prevent acidic corrosion. If the proper pH value could be provided and at the same time the water did not contain any free sodium hydroxide, both acidic corrosion and embrittlement could be prevented. The use of another alkaline agent such as trisodium phosphate will elevate the pH without introducing any free sodium hydroxide.

While the trisodium phosphate will ionize in a boiler water and thus produce hydroxyl ions (OH), when leakage and concentration occur the solid material deposited will be trisodium phosphate and not sodium hydroxide. Thus, the concentrated solution existing in contact with the solid deposit will be very much lower in hydroxide ion than if the deposit were sodium hydroxide from a boiler water containing free sodium hydroxide.

Figure 5 illustrates the approximate pH value of solutions of trisodium phosphate of various PO_4 content. If the boiler water contains no free sodium hydroxide (or the absence of any alkalinity other than that due to trisodium phosphate) the pH value of the boiler water should be at or below the curve for any corresponding PO_4 content. If pH values are above the curve, the presence of free sodium hydroxide is indicated. For plant control purposes this curve should serve only as a guide and it is advisable that the hydroxide ion content be checked by titration of the boiler water alkalinity by the strontium chloride method.

Unfortunately, there is one serious drawback to the coordinated pH-phosphate method which limits its use to a relatively few plants In most industrial plants where the boiler feed water contains bicarbonate or carbonate alkalinity, sodium hydroxide will be formed in the boiler water due to the breakdown of these compounds under boiler temperature. In such cases disodium phosphate, monosodium phosphate or even phosphoric acid is required in order to reduce the pH caused by the breakdown of the alkalinity. While it is theoretically possible to employ a sufficient quantity of phosphoric acid or monosodium phosphate to eliminate any free sodium hydroxide and reduce the pH of the boiler water to a value below the curve in Figure 5, the quantity of these reagents required may be enormous for the average industrial plant with appreciable quantities of make-up water. Under these conditons boiler-water solids will be increased to an undesirable extent. Therefore, the coordinated pH-phosphate control method of preventing embrittlement is applicable primarily to plants employing evaporated make-up water or for plants using a feed water composed almost entirely of condensate.

Chemical Inhibitors

Many chemical materials have been investigated for their properties as inhibitors of intercrystalline cracking. While many have been discarded as valueless in preventing this attack on boiler steel, many other materials have proved to be of value. No one material has yet been found suited to universal application. Each power plant presents its own individual problem and solution.

Among the various inhibitors available, the nitrate ion is of prime importance. Research has shown that the presence of small quantities of nitrate accelerate intercrystalline cracking. However, when nitrate is present in larger quantities it acts as an inhibitor, preventing embrittlement. When used to overcome embrittling characteristics of a boiler water, the control of sodium nitrate is based on a definite sodium nitrate-sodium hydroxide ratio in the boiler water. The ratio to be maintained will vary upon the operating conditions at the plant.

Sodium nitrate is stable under boiler conditions and has been successfully applied at pressures as high as 700 psi. It previously was feared that under pressure and temperature of boiler operation decomposition of the sodium nitrate might take place, releasing ammonia with the steam. However, analyses of condensed steam before and after the use of sodium nitrate indicate there is no significant breakdown or increase in ammonia.

Another chemical inhibitor employed for the pre-

vention of embrittlement is waste sulfite liquor, a by-product of the sulfite process of paper manufacture. The principal application of this inhibitor has been in locomotive boilers. Results with this material have not been entirely consistent and it appears that the sulfate and chloride ions found present in boiler water may destroy the protective action of this material under some circumstances. In addition, because of reported difficulties with foaming in the boiler water, waste sulfite liquor generally is not recommended for use in stationary boilers.

Quebracho tannin possesses very good inhibiting characteristics for the prevention of intercrystalline cracking and also has been employed at boiler pressures as high as 700 psi. Control is based on maintaining a definite tannin-sodium hydroxide ratio in the boiler water. The disadvantage of this material is that the boiler water may become so highly colored by the tannin that other routine control analyses may be seriously hampered. In additional, quebracho tannin which has been absorbed by boiler water precipitates is not effective, nor is quebracho which has become oxidized.

Many other materials have been shown in the course of laboratory research to be of value in preventing intercrystalline cracking. The phlobotannins, a group including cutch, gambier, hemlock, and mimosa as well as quebracho, in general possess inhibiting characteristics. Depside tannins such as chestnut, sumac and oak also are of value, but are generally required in larger quantities. Sulfites, zincates, chromates and lignin materials such as eugenol, vanillin and guaiacol have shown good possibilities in the course of laboratory research, but have not as yet been extensively applied to plant operation.

Conclusion

The prevention of embrittlement like the science of industrial water treatment in general, has made great progress within the last ten years. While universal standards have not as yet been established for the prevention of intercrystalline cracking, it can be stated positively that the danger of embrittlement can be eliminated in any power plant if embrittlement test runs are made and proper inhibitors are applied.

Much of the research work on intercrystalline cracking was done by Professor F. G. Straub at the University of Illinois and by the United States Bureau of Mines under the sponsorship of the Joint Research Committee on Boiler Feedwater Studies. This latter committee was responsible for the development of the embrittlement detector. Although the research work at the Bureau of Mines has been terminated, those laboratories which previously cooperated in the investigations are continuing this research program, and offer to industry their aid in the solution of the embrittlement problem.

Properties of Chlorine

1 cubic foot of chlorine (gas) weighs 0.2 pound at 60° F.
1 cubic foot of chlorine (liquid) weighs 91.0 pounds at 60° F.

LATENT HEAT OF VAPORIZATION:
108 But/pound at 32° F.
104 Btu/pound at 50° F.
100 Btu/pound at 68° F.
97 Btu/pound at 86° F.

SPECIFIC GRAVITY (GAS):
2.491 at 32° F. (Air: 1.000).

SPECIFIC GRAVITY (LIQUID):
1.558 at —28.5° F.
1.468 at 32° F.
1.41 at 68° F.

LIQUEFICATION TEMPERATURE:
At atm. pressure,—28° F.
At 1103 psi, 291° F. (Critical)

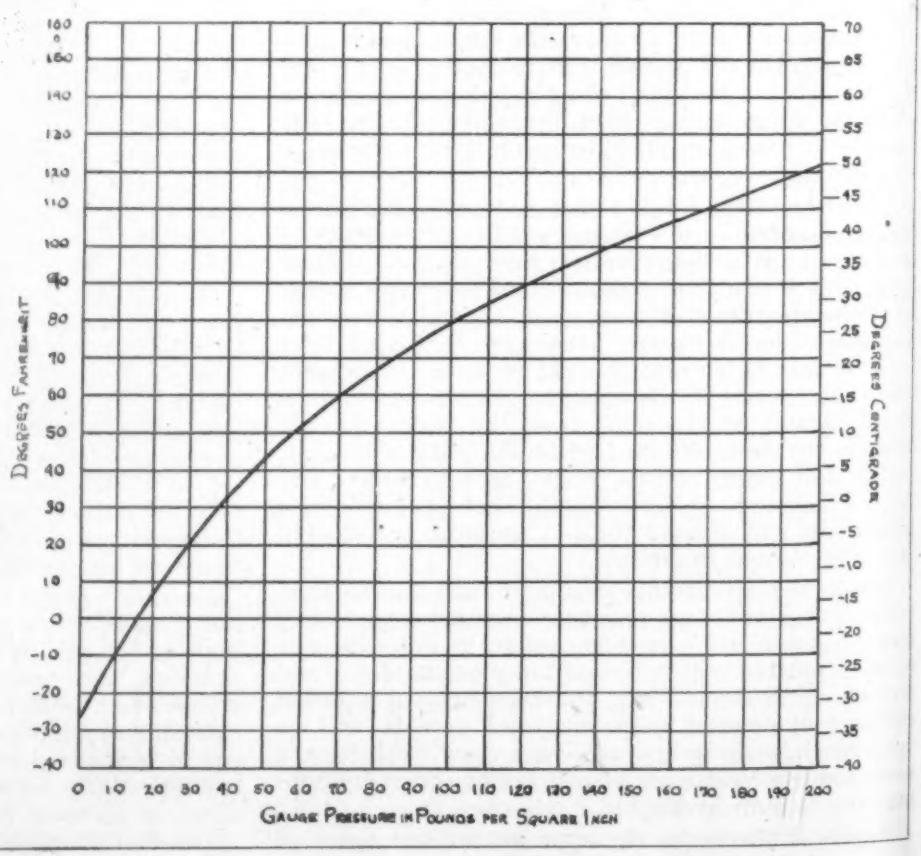
SPECIFIC HEAT:
Chlorine gas, 0.115 at 60° F.
Chlorine liquid, 0.225 at 60° F.

PRESSURE IN CONTAINER:
45 psi at 32° F.
110 psi at 80° F.

Liquid chlorine has a golden yellow color.

Chlorine in presence of moisture attacks practically all metals.

Dry chlorine does not attack iron at ordinary temperatures.


DEGREES FAHRENHEIT
DEGREES CENTIGRADE
GAUGE PRESSURE IN POUNDS PER SQUARE INCH
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200

Temperature-Pressure curve for liquid chlorine.

PLANT DESIGN OF
Compressor Piping

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ENGINEERS and designers of compressor stations in recent years have become conscious that the efficiency of a compressor plant can be increased by installation of the proper piping. The methods for arriving at the proper size and arrangement of compressor piping have made considerable progress in the past ten years and much work can yet be done on this subject. The old method of sizing the pipe to agree with the size of the pipe flange furnished with the compressor is obsolete. There are times when the compressor builder is forced to use a smaller opening in the compressor cylinder than correct for the maximum flow of that cylinder in order not to weaken the structure of the compressor-cylinder body. In cases of this kind, a swedge increasing the pipe to the proper size installed directly at the compressor flange causes so little pressure drop as to be negligible.

Calculation of the compressor piping sizes can be based on three fundamental methods: pressure-drop method, gas-velocity method, and mass-velocity method. The pressure-drop method consists of calculating the pressure drop through each piece of equipment and summing them all up to arrive at the total drop through the system. A maximum pressure drop is set and the piping so designed as to stay below it. As the pressure drop in station piping should be kept to at least 1 percent of the inlet pressure, Fanning's equation

$$\Delta P = \frac{.000001439\ f\ L_p V_g^2 \rho}{d}$$

can be used with perfect safety for calculating the pressure drop through the pipe. The other methods consist of establishing a maximum gas velocity or a maximum mass velocity and designing the piping to suit these velocities. The mass-velocity method is somewhat superior to the gas-velocity method due to the fact that it includes the density of the gas. In checking over the gas velocities used in modern gas-transportation systems we find that gas velocities in these lines average 1300 feet per minute. This we believe should not be exceeded in station piping inasmuch as this velocity is based on a steady flow which is unobtainable at present in a compressor station. For compressor headers where the pulsations are apt to be severe, a gas velocity of over 1000 feet per minute should not be used. The gas velocity referred to is the average linear velocity of the gas in the pipe. The average mass velocity for the lines mentioned above is 2000 pounds per minute per square foot, which figure should not be exceeded in the station piping. Again this mass velocity should be cut to not over 1500 pounds per minute per square foot for compressor headers where the pulsations are liable to be severe.

In the calculation of both the linear and the mass velocities the capacity of the compressor in cubic feet per minute should not be used as it will give quantities that are too low. The average momentary rate of flow also measured in cubic feet per minute should be used in all cases. It is true that with certain compressor-cylinder combinations at certain volumetric efficiencies the summation of the various compressor cylinder capacities will equal the summation of the various average momentary rates of flow and under these conditions only can the capacity figures be used. In order to facilitate the calculation of the average momentary rates of flow the curves on Figure 1 have been drawn. The notes on these curves make the use of them obvious. The foregoing is merely a method of arriving at the proper diameter

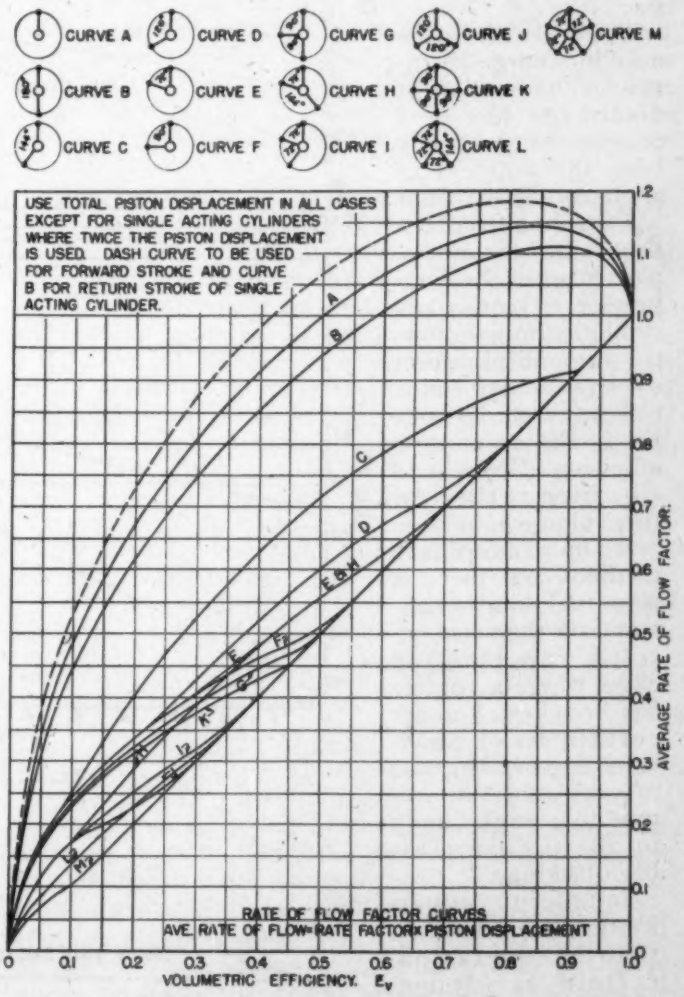

FIGURE 1

of the pipe lines in a compressor station so that the pressure loss through them will not decrease the capacity of the compressor cylinders themselves nor increase the power necessary to compress the gas through the desired pressure range. These calculations have no bearing on resonant conditions in the pipe lines, as this is purely a function of pipe-line length and not diameter.

In order to reduce as much as possible the pressure fluctuation produced by a reciprocating compressor, especially when only one compressor cylinder is connected to a pipe line, it is necessary to install surge chambers before the suction flange and after the discharge flange of the compressor cylinder. Although these surge chambers are deemed unnecessary by some, the plants that have been installed will show more gas moved per horsepower input than those plants that are without surge chambers. For a cylinder having a high vacuum suction, a surge chamber of some sort is imperative unless the suction line is enlarged out of proportion to the cylinder size.

The volume to be used in a surge chamber on the suction or discharge line of a compressor has long been the subject of argument. This volume has varied from ten times the piston displacement of the compressor cylinder per revolution to five times the piston displacement of the compressor cylinder per stroke times the volumetric efficiency. These and all other values for this volume have been based on rule-of-thumb methods and there is no actual data to substantiate their use except a few isolated cases where a volume has been tested under certain set of conditions. A general method of calculating this volume that might apply to all conditions has been lacking.

In order to derive a formula for all conditions of operation, certain assumptions must be made, or the formula becomes too complicated for ordinary engineering use. One assumption that can be made without causing too great an error is to assume that the gas flows from the surge chamber on the discharge side and to the surge chamber on the suction side at a constant rate based on time. This is not quite true as the flow from or to the surge chamber is governed by the pressure difference between it and the header into which it discharges in the case of a discharge surge chamber, and between it and the header from which it takes its supply in the case of a suction surge chamber. As the function of a surge chamber is to

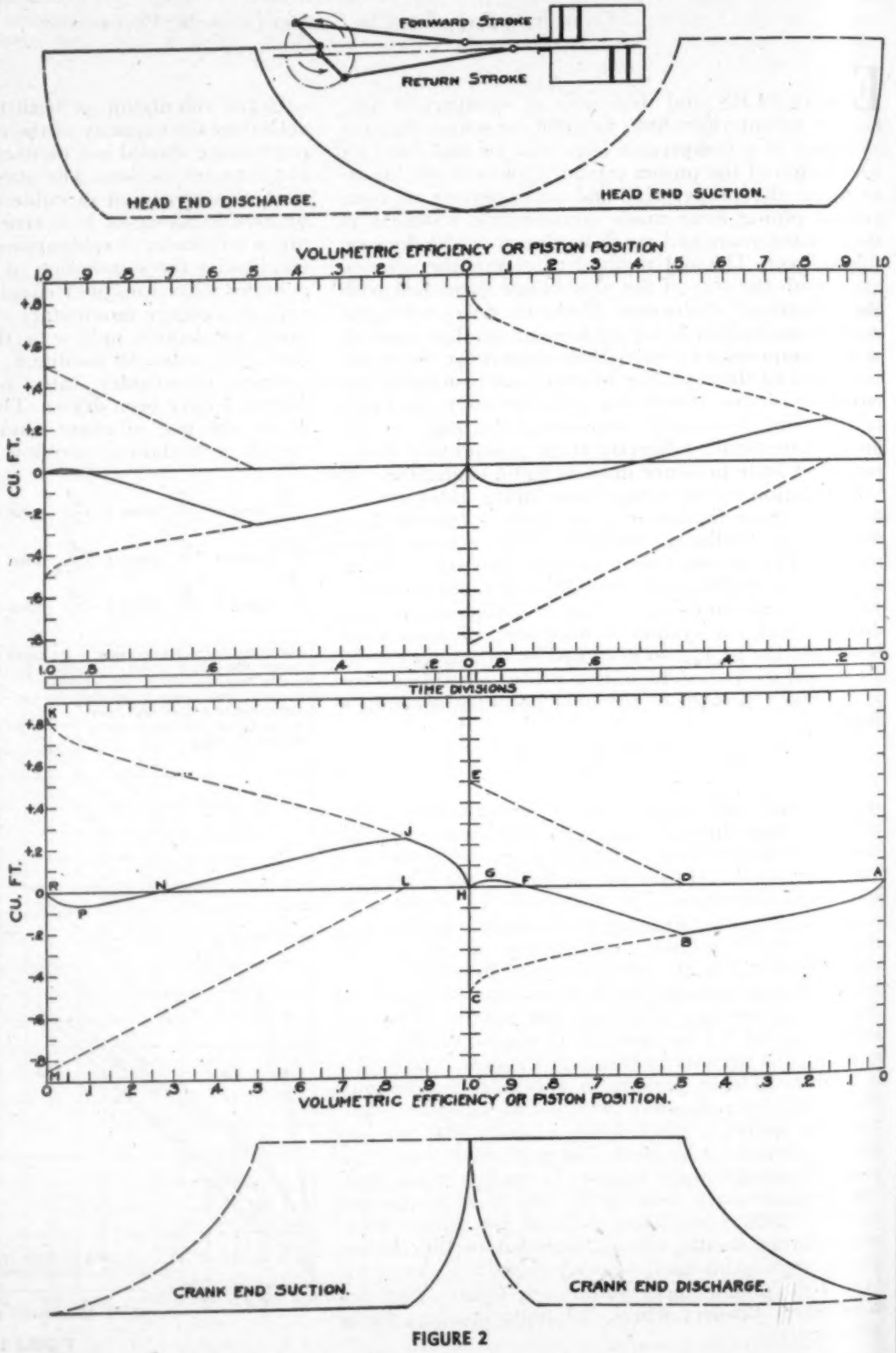

FIGURE 2

prevent large pressure fluctuations in the compressor piping, the pressure change in the surge chamber should not be of any magnitude and should not affect the flow to any great extent, therefore the assumption of a constant rate of flow should not cause too great an inaccuracy. As the volume of the surge chamber will depend upon the allowable pressure difference in the surge chamber, the volume of gas discharged from or the volume of gas delivered to the surge chamber must be known.

In order to maintain equilibruim in the surge chamber, the volume of gas flowing from the surge chamber must equal the volume delivered to the surge chamber by the compressor cylinder, therefore the volume flowing from the surge chamber during the time of one stroke is equal to the piston displacement times the volumetric efficiency of the compressor.

The easiest way of calculating the volumes delivered to and flowing from a surge chamber is graphically. Figure 2 is a graphical solution for a compressor cylinder having a stroke of one foot, a piston area of one square foot, or a piston displacement of one cubic foot per stroke and operating with a suction volumetric efficiency of 85 percent and a discharge volumetric efficiency of 50 percent. The heavy lines on the compressor cards at the top and bottom of Figure 2 show that stroke of the compressor depicted by the curves above and below them. The ordinates are divided in cubic feet, the plus quantities are the volumes delivered to the surge chamber and the minus quantities are those flowing from the surge chamber. The abscissa are divided in feet, showing the piston position or its equal the volumetric efficiency. The center scale is divided in divisions of periods of time during a stroke. The lower left hand set of curves are for the crank end discharge stroke. In this set of curves, the line ABC represents that amount of gas that flows from the discharge surge chamber into the discharge header during this stroke. As this flow is at a constant rate in regard to time and of an amount equal to the output of the compressor cylinder during the discharge stroke, or in this case 50 percent of the piston displacement or .5 cubic feet, the point C is at —.5 cubic feet. The flow being at a constant rate in regard to time it is equal to .05 cubic feet for every .1 of the time of one stroke. The time-division scale for this curve is between the two sets of curves. The gas continues to flow from the discharge surge chamber until the compressor piston reaches .5 of its stroke or at 50 percent volumetric efficiency line at which point the discharge valves open and the compressor starts discharging into the discharge surge chamber. The discharge rate of the compressor cylinder is at a constant rate with the piston movement so it will discharge .1 cubic foot for each .1 of the piston stroke. The line DE shows the output of the cylinder. The composite curve ABFGH represents the amount of gas delivered to or flowing from the discharge surge chamber. The low point of the curve B shows that the amount of gas that has flowed from the discharge surge chamber is .234 cubic feet. The curve also shows that toward the end of the stroke the compressor discharge overbalances the flow from the discharge surge chamber so as to give a positive value of .032 cubic feet, then the total volume change to be absorbed by the discharge surge chamber is .266 cubic feet. The curves for the crank-end suction are constructed in the same manner, only in this case the

Symbols Used

P = Pressure drop in lbs. per sq. in.
f = Fanning's friction factor.
L_p = Length of pipe in feet.
V_g = Linear velocity of the flowing fluid.
ρ = Density of the flowing fluid in lbs. per cu. ft.
d = Inside diameter of pipe in inches.
ΔV = Volume change in cu. ft.
Pd = Piston displacement in cu. ft. per stroke.
V_c = Surge chamber volume in cu. ft.
p = Discharge or suction pressure in psia.
p' = Allowable peak pressure in surge chamber in psia.
n = Polytropic exponent in the equation $PV = K$.
F = Natural frequency in cycles per second.
V_f = Velocity of sound in the flowing fluid at flowing temperature in ft. per second.
V_o = Velocity of sound in the flowing fluid at the base temperature in ft. per second.
T_f = Temperature of the flowing fluid at flowing temperature in °R.
T_o = Temperature of the flowing fluid at the base temperature in °R.
psia = Pounds per sq. in. absolute = Pounds gauge + atmospheric pressure.
°R = Degrees Rankine = °F. + 460.

gas flows from the suction header into the suction surge chamber and from it to the compressor cylinder. The line HJK represents the flow into the surge chamber and has a final value of .85 cubic feet, equal to the suction volumetric efficiency of the compressor cylinder. The line LM represents the withdrawal from the suction surge chamber by the compressor cylinder and also has a final value of —.85 cubic feet, and starts at the .85 percent efficiency line. The composite curve HJNPR represents the volume delivered to or withdrawn from the suction surge chamber. This curve shows that there is a volume change to be absorbed by the suction surge chamber of .298 cubic feet.

We now have the volumes that will cause a pressure fluctuation in both the suction and discharge surge chambers, and as they are based on a piston displacement of 1 cubic foot they can be used for any piston displacement by multiplying that piston displacement by them. In order to arrive at a definite value for the volume of a surge chamber we must place some limitation upon the amount of pressure fluctuation allowable in that surge chamber. Let us call the volumes causing the pressure fluctuation ΔV. They are a function of the piston displacement or $\Delta V = (FPd)$ where F is the factor derived from the curves. If we take p as the normal pressure in the surge chamber and p the allowable peak pressure in the surge chamber we can write

$$\frac{V_c + \Delta V}{V_c} = \left(\frac{p'}{p}\right)^{\frac{1}{n}}$$

where V_c equals the surge chamber volume. This equation can be reduced to

$$V_c = \frac{(FPd)}{\left(\frac{p'}{p}\right)^{\frac{1}{n}} - 1}$$

which allows us to calculate the volume required in a surge chamber when the desired pressure change in that chamber is known.

Figure 3 was developed in order to facilitate the computation of a surge chamber. This curve is a plot of the various volume changes in percent of piston displacement so that it can be used for a cylinder of any piston displacement. The ΔV factor is not the

same for the forward stroke as it is for the return stroke, and as the ΔV factor is always larger on the return stroke than on the forward stroke, it should be used for a double acting compressor cylinder.

In order to show the operation of Figure 3 the following problem is presented.

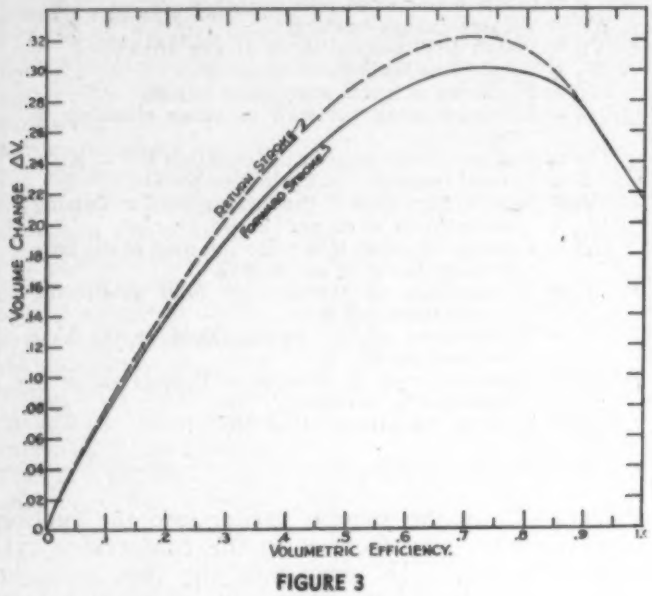

FIGURE 3

Problem: A double-acting compressor of 8-inch bore and 14-inch stroke is operating at 300 rpm with a suction pressure of 350 psia and a discharge pressure of 700 psia, compressing a gas having a normal n value of 1.306. What are the cubic contents necessary in the suction and discharge surge chambers to keep the pressure change in these chambers to within 2 percent of the suction and discharge pressures in the respective chambers? The compressor has an average clearance of 10 percent of the piston displacement.

From the above we find that the suction volumetric efficiency is 89.6 percent, that the discharge volumetric efficiency is 51.4 percent and that the average piston displacement per stroke is .3786 cubic feet. If the gas has an n value of 1.306 under normal conditions it will have an n value of 1.375 at suction conditions and an n value of 1.342 at discharge conditions. From Figure 3 we find the volume-change factor for 89.6 percent volumetric efficiency to be .2758 then the volume of the suction surge chamber will be

$$\frac{.2758 \times .3786}{\left(\frac{357}{350}\right)^{\frac{1}{1.375}} - 1} = 7.190 \text{ cubic feet.}$$

For the discharge surge chamber the volumetric efficiency of 51.4 percent produces a volume change factor of .2908 and the volume of the discharge surge chamber will be

$$\frac{.2908 \times .3786}{\left(\frac{714}{700}\right)^{\frac{1}{1.342}} - 1} = 7.388 \text{ cubic feet.}$$

In this case we find that the discharge surge chamber is actually slightly larger than the suction surge chamber due to the fact that during the discharge stroke a greater volume change takes place than during the suction stroke. This is not always the case, as the volume change, which governs the volume of the surge chamber, depends on the volumetric efficiency, provided the percent of pressure rise in the surge chamber is the same.

The object of the surge chambers is to dampen or decrease as much as possible the pressure fluctuations in the pipe lines leading to and from the compressor cylinder. These pressure fluctuations are the producers of pipe-line vibrations which in some cases produce failures in the pipe. At the present but very little is known about the action of gases under pressure and fluctuating flow in a network of piping such as in a compressor station, but we do have basic formulae for the natural frequencies in simple pipes. The fundamental resonant frequency of a pipe closed at one end is $F = V_t/4L_p$. This can, too, be used for the pipe between the compressor cylinder and the surge chamber and this frequency and that of the second harmonic should be avoided in this case. The fundamental resonant frequency of a pipe open at both ends is $F = V_t/2L_p$. This can be used used for the pipe between the surge chamber and the station header, and this frequency and that of the third harmonic should be avoided in this case. The velocity of sound in the gas can be calculated by the formula

$$V_s = 68.05\left(\frac{np}{\rho}\right)^{1/2}$$

In this equation the values for n and ρ must be those at the pressure p. As these values are generally given at some temperature other than that of the flowing gas a temperature correction

$$V_t = V_s\left(\frac{T_t}{T_s}\right)^{1/2}$$

should be used and the final equation would be

$$V_t = 68.05\left[\frac{T_t np}{T_s \rho}\right]^{1/2}$$

where T_t is the absolute temperature at which the values n and ρ were taken. If we take the operating conditions of the previous problem and assume an inlet temperature of 68° F. and a discharge temperature 188° F. we find that the velocity of sound in the gas will be 1443 feet per second in the suction stream and 1616 feet per second in the discharge stream. As the unit is operating at 300 rpm and the compressor cylinder is double acting there are 600 impulses in the lines to and from the compressor cylinder each minute, or 10 per second. A natural frequency of 10 cycles per second is to be avoided in all piping and also a frequency of 20 cycles per second in the piping from the compressor to the surge chamber and also a frequency of 30 cycles in the pipe between the surge chamber and the station header. Substituting these values in the frequency equations we find that in the suction pipes lengths of 38.08 feet and 12.69 feet are to be avoided in the line from the station header to the surge chamber and lengths of 72-15 feet and 36.07 feet in the line from the surge chamber to the compressor cylinder. On the discharge side we find that the bad lengths are 80.8 feet and 40.4 feet for the pipe from the compressor cylinder to the surge chamber and 40.4 feet and 13.48 feet for the pipe from the surge chamber to the station header. This is a simple problem easily solved but the situation when several cylinders are connected together becomes quite complex and is more easily solved by combining a graphical and algebraic method.

In the above we have endeavored to present the basic factors entering into the calculation of compressor piping. To present anything but these factors would require more space than permitted, as the various ways in which a compressor station can be piped are infinite.

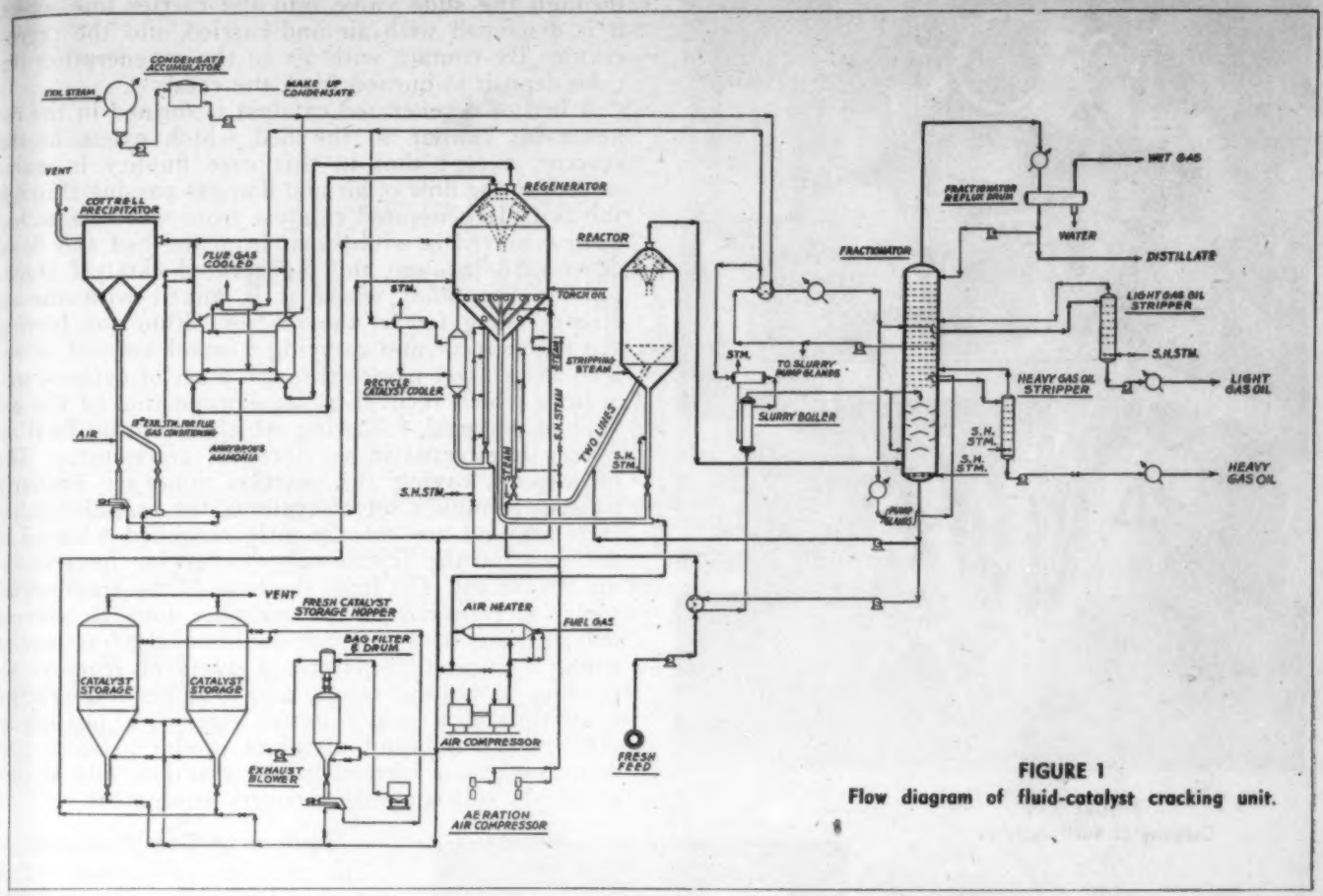

FIGURE 1
Flow diagram of fluid-catalyst cracking unit.

Mechanism
Of Flow in
Fluid-Catalyst Cracking

HENRY P. WICKHAM
Process Engineer, The M. W. Kellogg Company

THIS discussion covers many general aspects of fluid-catalyst cracking, the mechanics of catalyst flow being shown as a highly technical problem which must be approached with a background for which it is intended.

The paper was presented before the Metropolitan Section of the American Society of Mechanical Engineers at New York, May 10, 1945.

THE subject of catalytic cracking is one of great interest to most engineers. The cracking operation itself is amazingly simple, and yet great numbers of trained technologists have concentrated their efforts on every detail to insure the satisfactory performance of the many cracking units installed. While the development of this process has been rapid during the war period, security restrictions have prevented publication of the details of the operation until recently.

Prior to the outbreak of the war, catalytic-cracking operations were limited to a number of fixed-bed units and pilot plants of more recent designs. No commercial fluid-catalyst cracking units were in operation. At this stage of the development the primary interest in catalytic cracking was the production of fuel which would provide a high anti-knock rating without the use of uneconomically large quantities of tetra-ethyl lead. When war was declared, the demand for aviation gasoline of high quality increased, and production facilities involving catalytic cracking, alkylation, and associated refinery operations were rapidly expanded by installation of units at strategic locations about the country. Of the catalytic-cracking capacity for conversion of gasoil to products required by the war effort installed in this expansion program, about two thirds was of the fluid type.

It is hardly necessary to point out to a group of this type that catalytic operations are becoming more important every day in promoting chemical reactions. In fluid-catalyst operations the catalyst is used in the form of a coarse powder. When agitated or mixed with an aerating gas, the catalyst takes on the properties of a fluid in which condition it will flow

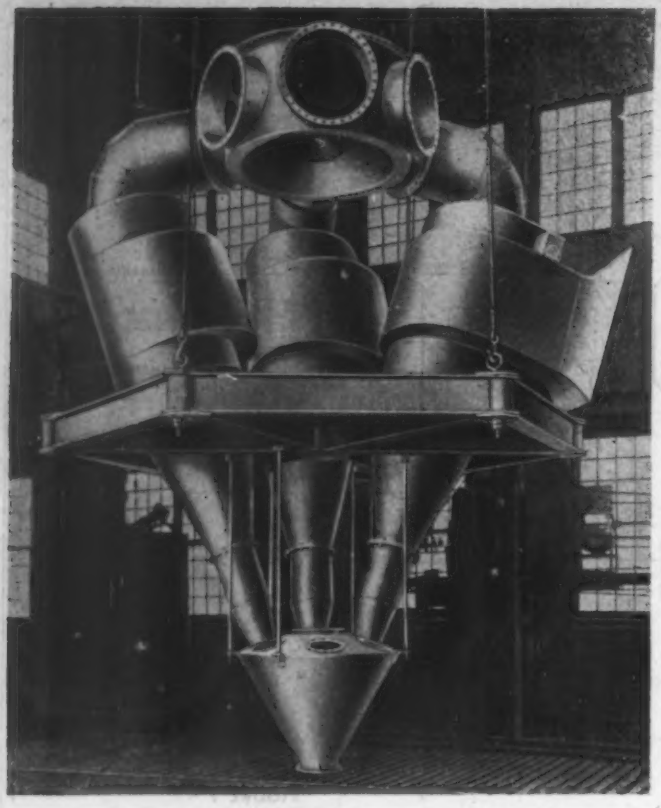

FIGURE 2
Cutaway of Buell cyclones

freely from point to point as required by the process. Aside from the ease of handling powdered catalysts, much of the difficulty of catalyst manufacture is eliminated, and almost any catalytic material can easily be prepared for the fluid type of operation. As catalytic operations are extended and applied to new processes, the inherent adaptability of the fluid-type operation should make it a leader in the field.

The catalyst employed in fluid-catalyst cracking is comprised of an activated silica-alumina mixture which has an average particle diameter of about 50 microns, with small amounts of material less than 10 microns. It is not essential to satisfactory operation that a rigid size specification be followed, and commercial plants have operated satisfactorily with a 0-20 micron fraction of 0 to 40 percent. It is also significant that variations in density, roughness and hardness are allowable, although it would not be desirable to employ a fragile material which would continually break down to smaller particles.

In the cracking operation, which is show on the flow sheet, Figure 1, oil and catalyst enter the reactor in which cracking proceeds. The catalyst settles from the products of reaction forming a fluid bed maintained in this condition by the upward flow of the entering vapors. As a result of the cracking reactions, coke is deposited upon the catalyst. The spent catalyst, carrying the coke deposit, flows downward through a stream stripping section, thence through the spent catalyst standpipe, and is released through the slide valve into the carrier line where it is dispersed with air and carried into the regenerator. By contact with air in the regeneration the coke deposit is burned from the catalyst.

A bed of regenerated catalyst is formed in the regenerator similar to the bed which exists in the reactor, except that in this case fluidity is maintained by the flow of air and flue gas passing through the bed. Regenerated catalyst from which coke has been removed is withdrawn from the bed and flows downward through the regenerated catalyst standpipe to the point where it is mixed with the oil stream being fed to the reactor. Flue gas leaving the regenerator and carrying a small amount of entrained catalyst passes through a set of cyclone separators which recover a large proportion of the entrained material, following which operation final recovery is effected in an electrical precipitator. The oil vapors leaving the reaction zone are similarly passed through a set of cyclones for partial catalyst recovery and are subsequently scrubbed with oil in the base of the fractionator tower for final clean-up of catalyst. Oil from the base of the fractionator tower is returned to the reaction zone to prevent loss of catalyst. The upper section of the fractionator tower is used to separate products of reaction according to boiling range, and it is general practice to withdraw a heavy gasoil stream, a heating-oil stream, and a liquid distillate product. Some condensable gas is formed in the reaction, and is processed in subsequently recovery equipment.

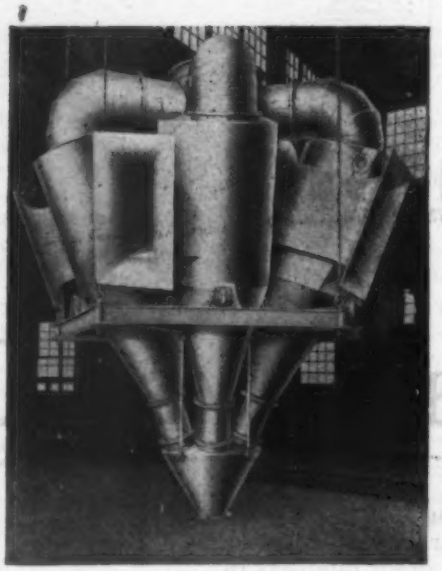

FIGURE 3
Cyclone assembly

Equipment Complications

The reaction is carried out at temperatures in the order of 900 to 1000° F. and the regeneration operation is carried out at still higher temperatures— around 1100° F. As a result of this temperature difference it is apparent that the circulation of catalyst serves also as a means of transferring heat from the regenerator to the reaction system, and this transfer may be so extensive as to permit charging cold liquid oil to the reactor inlet, while maintaining the desired temperature in the reaction zone.

Although the cracking operation is extremely simple, several complications are present in engineering considerations of the design of the equipment employed. The vessels and piping must be able to withstand the operating tempreatures. Metal expansion must be given careful consideration in the design and arrangement of the standpipes and carrier lines provided for the circulation of catalyst. The operating temperatures are in a maximum range where carbon steel has been found practical, and in some units chrome-moly alloys have been considered advisable. It is general practice to design on the basis of creep strength at these elevated temperatures. It is also general practice to protect the regenerator itself from the high operating temperatures with an internal liner of insulating material and, in some cases internal insulation has been used in the lines of the regeneration system.

As pointed out above, the circulating catalyst performs numerous functions in the operation. Besides promoting the desired reaction, it serves as a means

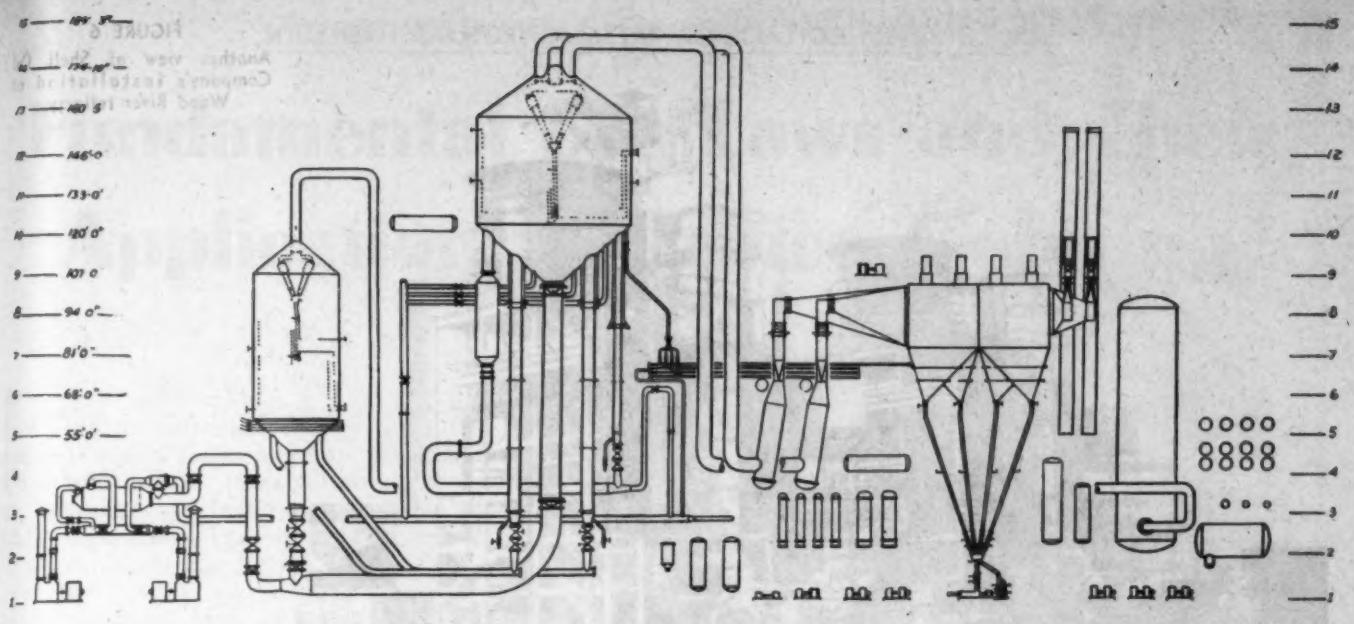

FIGURE 4
Physical arrangement of a typical fluid-catalyst unit, emphasizing height.

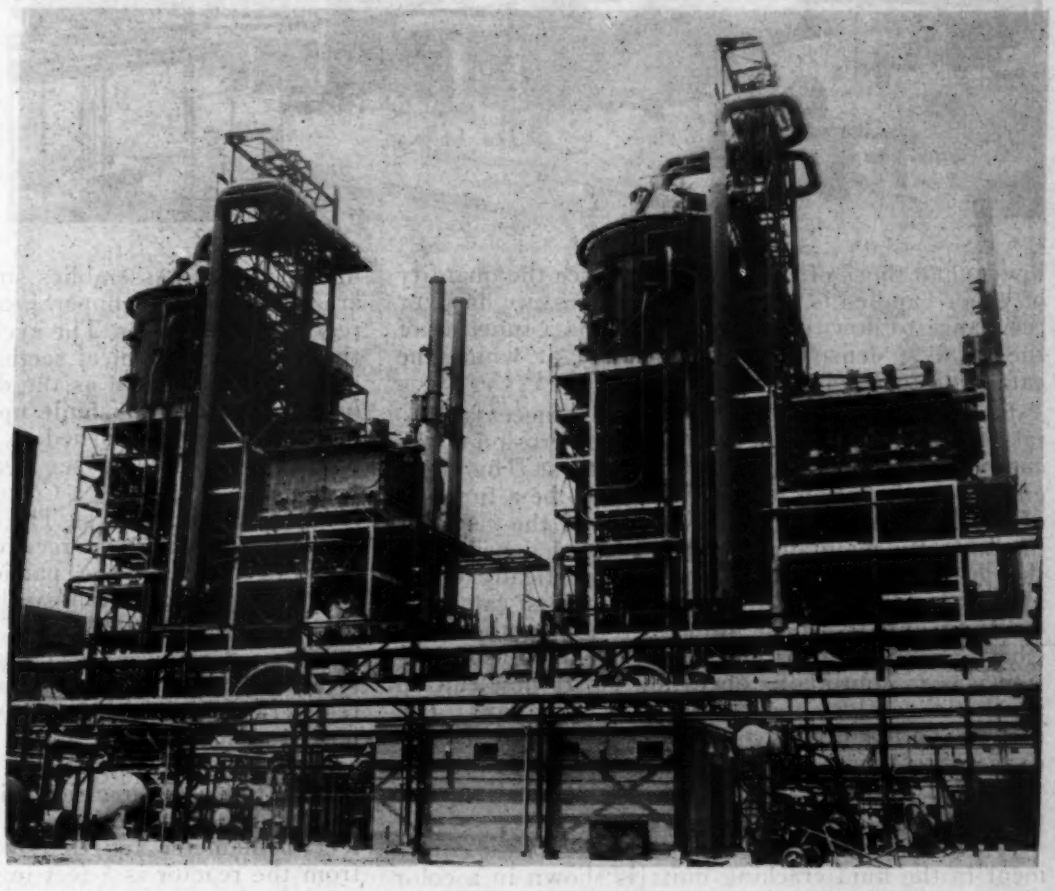

FIGURE 5
Twin fluid-catalyst cracking units in Shell Oil Company's refinery at Wood River, Illinois.

of transferring heat to the reaction zone and removing coke produced in the reaction from this zone. The quantity of catalyst must be under close control so as to maintain the desired reaction conditions. In designing this type of unit it is apparent that pressure drop through the carrier lines and pressure build-up in the standpipes is of great importance. In simple terms, each circuit for the transfer of catalyst may be likened to a U-tube in which the density on one side is maintained at a sufficient value to offset the pressure drop against the desired flow on the other side. Actually, the standpipes are designed to give more than the rquired pressure build-up so that the slide valve at the base of the standpipe may be used as the final point of control.

Density and fluidity are controlled in the standpipes provided by the admission of small amounts of aeration gas at various points. By increasing the amount of aeration gas admitted, the standpipe density may be reduced over a limited range. Once flow has been established in the standpipe, aeration gas is no longer necessary to maintain fluidity since sufficient agitation is provided as a result of flow.

The transfer of catalyst in the carrier lines is effected by velocities in the order of 30 feet per second. Carrier line densities are, of course, much

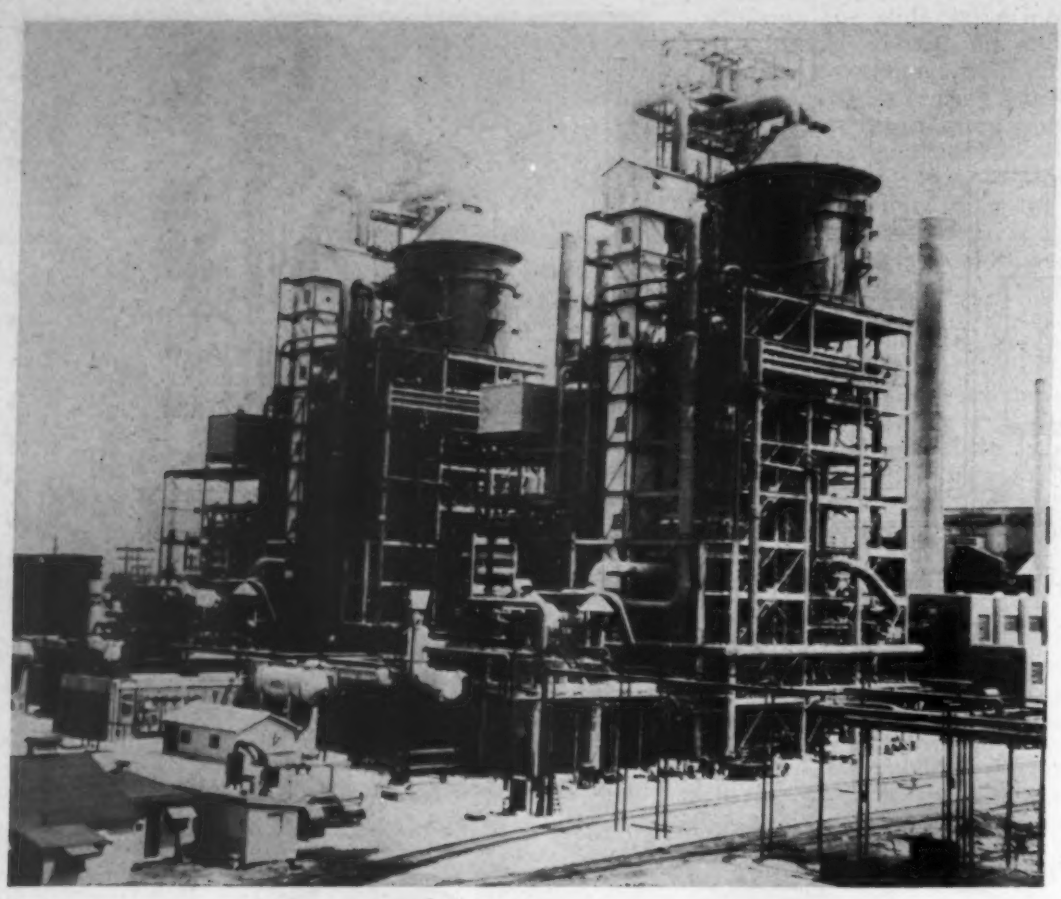

FIGURE 6
Another view of Shell Oil Company's installation at Wood River refinery.

lower than those of the standpipes since the quantity of vapor handled is very large. The pressure drop, or resistance to flow, in the carrier line is a function of the catalyst density and the velocity at which the catalyst is carried.

Experience has indicated that it is necessary to take certain precautions against undue erosion of the catalyst piping by the circulating catalyst. This tendency toward erosion has been found to be a function of catalyst density and the velocity of the carrying medium. By maintaining velocities and densities in the proper order, erosion may be practically eliminated, as witnessed by the fact that the first catalytic-cracking unit to be put into operation in the Lake Charles refinery of Cities Service Refining Corporation was in continuous operation on its first run on synthetic catalyst for a period of 300 days. The second and third units completed runs of 333 and 287 days, respectively, and all three units were shut down voluntarily and not by the need of repair work on the equipment.

A somewhat more picturesque version of the equipment in the fluid cracking unit [is shown in a color diagram which was reproduced in PETROLEUM REFINER, May, 1945, page 128]. Circulation systems for regenerated and spent catalysts are clearly indicated. The carrier lines terminate in the larger vessels and after distribution of the entering catalyst, a fluidized bed is formed in the vessel. The density of the bed depends upon the velocity of the rising vapors. At higher velocities lower densities will be found. The catalyst characteristics also affect bed density, and as particle size and particle density increase, the operating density increases at a given vapor velocity.

The vapors leaving the catalyst bed carry a small amount of entrained catalyst, a large portion of which is recovered by cyclone separating equipment (Figures 2 and 3). Assemblies similar to the one shown are located in the upper heads of the reaction and regeneration vessels. The cyclones deliver catalyst at the apex of the conical section to a small standpipe, generally designated as the dip-leg, in which a head of dense catalyst is built up so that the recovered material may be returned to the bed. As stated previously, the flue gases leaving the regenerator cyclones flow through a Cottrell precipitator for final recovery of the catalyst. The combined actions of the electrical and cyclone recovery equipment is sufficient to maintain the particle distribution of the circulating catalyst almost identical with that of the catalyst charged to the unit.

Figure 4 shows the physical arrangement of a typical plant with special emphasis on heights. The regenerator which is about 40 feet in diameter is supported about 120 feet above grade with the reactor somewhat lower at about 60 feet. Here may be seen the rotation and expansion joints required in the main carrier system. The spent catalyst carrier line is 6 feet in diameter and the standpipe feeding catalyst from the reactor is 5 feet in size. The highest steelwork in the structure is nearly 200 feet above ground level, but it must be remembered that the tremendous size of the equipment required by a plant of this capacity is a pertinent factor in the over-all height. The top and bottom cones of the regenerator take up about 40 feet and the tops of the slide valves are of necessity about 20 feet above grade. Smaller units naturally employ smaller vessels and piping and, therefore, require considerably less vertical height.

The complete unit shown is the previous illustrations appears in Figures 5 and 6. Actually two units were installed in this refinery as a part of the company's contribution to the war effort in the manufacture of aviation gasoline.

Fundamental Gas Laws and Their Application to Orifice Metering

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IN THE measurement of a gas by any of the various methods available, for example the orifice meter or the displacement meter, three variables are used to express the amount of gas being considered: pressure, volume and temperature. The behavior of a gas, when one of these variables has been changed, has been studied over many years, and various investigators have developed certain laws of behavior known as fundamental gas laws. However, these are only statements of behavior and do not explain why the gas acts the way it does. A few brief statements as to the physical state of gases will bring out the reasons why.

All matter is composed of molecules, that is the smallest unit to which a substance can be divided and yet retain its identity. These molecules are in constant vibration even when in a solid or liquid state. Their speed and length of travel depends upon the temperature, or, state in which the substance exists; say a solid, liquid or gas. In a solid or liquid state the molecules do not have the speed to overcome the cohesive forces between the molecules. However, in gases the speed of the molecules is greater than the attraction for each other and the molecules are far apart in comparison to their diameter. All gases can be liquefied at suitably low temperatures and high enough pressure. Gases at ordinary temperatures and pressures are to be considered as the super-heated vapors of low-boiling compounds. Vapors are the gaseous state of compounds near their boiling point and can account for any deviation from the fundamental gas laws.

In a gas the molecules move about with a great speed, and it is the constant pounding of these molecules upon the walls of the containing vessel that we measure as pressure. Temperature increases the speed of the molecules and the increased speed raises the pressure of the gas in the confining vessels.

Since the molecular motion theory can explain the reaction of gases to pressure and temperature it follows that this theory can give a basis for the measurement of these quantities. This starting point is that point where there is no molecular activity at all, or for pressure a perfect vacuum, and for temperature absolute zero. For the measurement of pressure in absolute units it is necessary to determine the atmospheric pressure as the atmosphere surrounds all things on earth. The conventional method is to read a mercury barometer. This device is made by filling a glass tube about 34 inches long, sealed at one end, with mercury and placing it in an inverted position in a reservoir of mercury. Necessary precautions are taken so that no water vapor or air is trapped in the tube which would affect the degree of vacuum in the barometer. By means of a suitable scale the height to which the mercury stands is measured. The absolute pressure, then, within a container is the gauge pressure plus the barometric pressure, both of course in the same units. For example we have a pipe line that has 20 pounds gauge and a barometer reading of 14.7 pounds, the absolute pressure would then be 34.7 pounds per square inch.

THIS paper is one of several which Petroleum Refiner is privileged to offer through the facilities of the Southern California Meter Association. The several papers are known as the "Meter Course," which has been in such demand that some means of giving the information wider distribution became essential. While Petroleum Refiner may not be able to print all papers of this "Meter Course," the several selected will satisfy the need for wider distribution.

Since the objectives of a publication are much like those of the Southern California Meter Association, a quotation from R. N. Christiansen, chairman of publicity, is offered as further explanation:

"The association was founded in 1927 for the dual purpose of ascertaining and publishing facts wherever differences of practice, procedure or opinion regarding fluid meters exist.

"Monthly meetings are held. Following the dinner, during which some professional music is furnished (usually accompanied by some non-professional singing) the papers are presented. Occasionally the meetings are augmented by a speaker who covers a timely and interesting topic not pertaining to the field of measurement. A "High Jinks" and "Low Jinks" are held annually. These are strictly good-time stag parties with dinner and show."

The point of no molecular activity on the temperature scale gives the zero point for absolute temperature. This point, known as absolute zero, has been determined by several ways to be —459.6° F. or —460° F. as used in most calculations. One method of determining this value has been to measure the contraction in volume of hydrogen at constant pressure in a container filled at 0° F. when the temperature is lowered 1° F. This contraction has been found to be 1/459.6 of the original volume. If the contraction is measured at other lower temperatures, the absolute zero by extrapolation would be found to be the above value. The absolute temperature can then be found by adding to the observed thermometer reading 460° F. Since the standard cubic foot of gas measurement for California has been defined at 14.73 pounds per square inch and 60° F., these are in absolute units 14.73 pounds per square inch absolute and 520° F.

Fundamental Gas Laws

Now as to the fundamental gas law. The relationship between pressure and volume was discovered by Boyle, an English scientist, in 1600. He found that the volume occupied by a given weight of gas was decreased to one half of the original volume when the pressure was doubled, with the temperature kept constant. In other words, if the temperature is kept

constant the volume will vary inversely as the absolute pressure. Mathematically this is expressed by the equation:

$$P_1V_1 = P_2V_2$$

where P_1V_1 is the pressure and volume under one set of conditions and P_2V_2 under the second set of conditions.

For example, what is the volume at 40 pounds absolute at 60° F. of 4000 cubic feet initially at 20 pounds and 60° F.? The answer is found by the expression:

$$V_2 = \frac{P_1V_1}{P_2} = \frac{4000 \times 20}{40} = 2000 \text{ cu. ft.}$$

Charles' law, also discovered by others, states that the temperature-volume relationship of a given weight of gas, pressure being constant, is expressed by the statement that its volume varies directly with the temperature. Again mathematically it is expressed by:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Again, for example, the above gas was heated to 520° F. or 1040° absolute at 40 pounds absolute, what is the new volume?

$$\frac{2000 \times 1040}{(60 + 420)} = 4000 \text{ cu. ft.}$$
$$520$$

Both of these laws can be combined into the one law, that of the perfect gas law.

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} = \text{a constant.}$$

By means of these equations and the combined form, the measurement of the volume of any gas at moderate pressures and temperatures can be converted to the standard cubic foot at 14.73 pounds absolute and 60° F.

The perfect gas law can also be expressed in the form

$$PV = nRT.$$

where n = the pounds of gas and R the gas constant for the gas in question which is $\frac{1544}{m}$ when m is the molecular weight of the gas and 1544 the universal gas constant. P in this expression is in pounds per square foot absolute. Usually the expression is reduced to the form

$$PV = 10.72\,NT$$

where P is in pounds per square inch absolute V is in cubic feet, N is the pound mols, and T the absolute temperature. A pound mol of any substance, gas, liquid or solid is a quantity whose weight in pounds is the same as its molecular weight. This holds true for all true gases.

It was early realized that all of the gases are not perfect gases and the additional factor Z—deviation factor, has been added to the above expression:

$$PV = 10.72\,ZNT.$$

This deviation factor, Z, can only be determined experimentally and is of great use in the measurement of gases at high pressures. The determination and use of deviation or compressibility factors, known as PV, will be covered, I understand, in a later paper.

The pound mol is used in many chemical calculations and can be used to calculate the density or weight of 1 cubic foot of any gas at standard conditions. First of all it is necessary to determine the volume of a pound of mol of gas at our standard conditions of 14.73 pounds and 60° F. Solving the perfect gas law for V for 1 pound mol of gas.

$$V = \frac{1 \times 10.72 \times 520}{14.73} = 378.4$$

We find that V equals 378.4 cubic feet at 14.73 pounds and 60° F., or as used in most calculations 372 cubic feet. Then the density of any gas can be found by dividing the molecular weight in pounds by 378. For example, oxygen has a molecular weight of 32.00, therefore, its density would be 0.0846 pounds per cubic foot at 14.73 pounds and 60° F.

Air is composed of approximately 79 percent nitrogen and 21 percent oxygen with small traces of carbon dioxide and the rare gases which give it a molecular weight of 29.0. If the specific gravity of a gas to air is known, its molecular weight is 29.0 × G = molecular weight of the gas, for example:

$$29.0 \times .60 = 17.4$$

The determined density of air is 0.07654 pounds per cubic foot at 14.73 pounds absolute and 60° F.

A further use of the basic gas laws is to calculate the effect of changes in pressure or temperature upon the density of any gas. Gravity, expressed by the use of the letter G, or more properly the specific gravity, is the ratio of the weight of one standard cubic foot of the gas to the weight of one standard cubic foot of air being used as the base. Therefore, the density of the gas would be the weight of 1 cubic foot of air multiplied by its specific gravity.

The combined gas laws are used to compute the changes in density by the following expression:

$$d_2 = \frac{d_1 \times 520 \times P_2}{T_2 \times 14.73}$$

For example what is the density of a gas at 80° that has a gravity of .75 at a constant pressure of 14.73 pounds?

$$d_{80} = \frac{0.07654 \times .75 \times 520 \times 14.73}{(460 + 80) \times 14.73} = 0.0574 \text{ lbs. per cu. ft.}$$
$$540$$

If, in addition, the pressure was increased to 15 pounds gauge, the density would be

$$d_{80} \text{ \& } 15\# \text{ ga.} = \frac{0.07654 \times .75 \times 520 \times (15 + 14.73)}{540 \times 14.73} \quad \begin{matrix} 29.73 \\ \\ \end{matrix}$$
$$= 0.1159 \text{ lbs. per cu. ft.}$$

Since it is known that the gases deviate from the perfect gas law, and if for a particular case the deviation factor, Z, has been determined or estimated by one of several methods published at various times, the density of a gas can be calculated by means of the perfect gas law:

$$PV = ZNRT$$

$$\text{from which density} = \frac{1}{V} = \frac{P}{ZNRT}.$$

Here again we may take the previous example where the gas has a gravity of .60 or molecular weight of 17.4 and a Z factor of .725 for a pressure of 1900 pounds absolute and 80° F. In this case we will use 1 pound of the gas to calculate the density

$$\text{Density} = \frac{1900}{\frac{1}{.725 \times 17.4 \times 10.72 \times 540}}$$

$$\text{Density} = 7.877 \text{ lbs. per cu. ft.}$$

In conclusion the fundamental gas laws are a very useful tool to make computations as to what happens to a given weight of gas when the pressure and temperature are changed, and with the introduction of the deviation factor we are able to apply them to problems involving the measurement of gas at any pressure and temperature.

Fundamentals of Orifice Meter Measurement

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Signal Oil & Gas Company

SPEAKING of fundamentals, the first point to explore is to learn what makes an orifice meter. An hourglass is an example of the basic operating principle of the orifice meter. It was essentially not a recording type, but it measured time by the same elements thaat constitute an orifice meter. The basic elements of an orifice meter are a conduit or pipe and a means of restricting the fluid flow.

The orifice is the most commonly used means of restricting the flow. In 1797, Venturi, an Italian physicist, experimented with orifices and some of the present-day types of modified orifices are related to his work. The Venturi meter is a special type of orifice and finds usefulness in many places. Orifices may be of different design. There are sharp-edged, round-edged or beveled-edged orifices, and all are used for the purpose of restricting the flow to create a measurable change of energy.

It was not until 1903, or later, that T. R. Weymouth did most of his experimental work on orifice meters. His principal purpose was to develop a means of measuring gas in closed conduits, and particularly the larger volumes of gas. His original measurements were made by instantaneous observations of the readings of a water column.

The water column served well for tests, but was unsatisfactory for use in the later type meters with recorders. However, Weymouth did set up recommendations for orifice-meter measurement that have aided in developing and maintaining standards and also duplicable installations. Some of his early recommendations include, that the orifice thickness be limited to one eighth of the diameter of the orifice, that there be 10 pipe diameters of straight run of unobstructed pipe upstream and downstream from the orifice and also that the differential in inches of water be kept less than the static pressure in pounds per square inch absolute. These recommendations cover the basic installations today.

The present orifice meter is simply a standardized means of restricting or impeding flow. If we place any impediment in a gas line we will create a pressure drop, and the amount of pressure drop will increase with the rate of the flow. Conversely, there will be no pressure drop at zero flow rate.

Experimentally, it has been found that within reasonable accuracy, that thin, sharp, square-edged orifice plates of a given diameter would create the same pressure drop at the same rate of flow. In such a manner, this type of orifice plate has been standardized and further specified. Other physical requirements of the orifice meter have been specified largely to standardize all the elements of the meter. Thus, a tolerance of accuracy may be established and meter runs may be duplicated with comparable results.

Through the experimental development, different investigators were responsible for certain changes. Weymouth developed the commonly used flange type meter set-up with the pressure taps at the orifice flanges. Later Hickstein and Fisher developed the pipe tap connections, with the pressure taps 2½ diameters upstream and 8 diameters downstream of the orifice. The pipe taps were to avoid the impact effects at the upstream face of the orifice and away from the pressure recovery effects downstream.

The empirical coefficients developed by the same investigators were used without question until 1924. At that time the American Gas Association initiated a ten-year study of the sharp, thin plate, square-edged orifices. The results of this investigation are the present coefficients now in use and the standard requirements for orifice meter installations, which were published as Report No. 2, of the Gas Measurement Committee of the American Gas Association. In this report are complete specifications for the orifice plate, and the meter run and also all the coefficient data relative to gas measurement.

What Happens in Orifice Meter

Our next problem is to learn what happens in an orifice meter. When measuring gases we know that we have a pressure that is related to absolute pressure, and that when a flow exists there is a difference of pressure upstream and downstream of the orifice that we call the differential pressure. To determine the actual rate of flow, it is necessary to make certain calculations using the values of the absolute pressure and differential pressure.

Normally, our problem is to apply a coefficient or multiplying factor to the square root of the product of the absolute pressure and the differential readings, when using direct-reading charts.

However, the meter chart and readings are the result of what occurs in an orifice meter. Actually our orifice meter is recording a change in the energy relations of the gas as it passes through the orifice plate. The differential pressure across the orifice means that the pressure downstream of the orifice plate is less than the upstream pressure. Therefore, the volume occupied by the gas downstream of the orifice is greater than the volume of the gas upstream of the orifice due to this reduction of pressure. For this same reason, the velocity downstream of the orifice is higher than the velocity of the gas upstream. Now all of these changes of conditions make it possible to derive an equation which relates the changes of energy of the fluid.

So, the basic coefficient is an equation of energy that measures the work done in passing the gas through the orifice. Since work involves horsepower, our measurement is in terms of pounds of gas moving through feet of pipe a minute. Horsepower is foot-pounds of work done in a certain time. Now that we have related our measurement to feet per second

(velocity) and pounds (weight), it is possible to explain the performance of a recorder of an orifice meter in relation to the pipe-line flow.

For an example, air is flowing through an orifice meter at a rate of 1 pound per minute, the upstream pressure is slightly above atmospheric and the differential pressure reading is 5 inches of water. This condition of flow will provide the energy for a certain amount of work. The 10 pounds of air we will estimate to equal about 240 cubic feet at atmospheric pressure. Therefore, its velocity in a 6-inch standard pipe under 15 pounds absolute pressure would be about 48 feet per minute.

Now, let us see what would happen if, instead of air, we use a gas of 0.75 specific gravity. This means that 7.5 pounds of this gas will equal 240 cubic feet of volume at atmospheric pressure. And since this volume of gas passing through the orifice in the same period of time will not do the same amount of work as the air and create the same differential, a greater volume of gas flowing at a higher velocity would be necessary to create the same differential-pressure reading and do the equivalent work done by the air.

By further contrast, a heavy vapor of 1.5 specific gravity would weigh 15 pounds for the same 240 cubic feet of atmospheric conditions. Therefore, this vapor to produce the same amount of work as the air would require less in volume and consequently a lower velocity to produce the same differential reading.

By these comparisons, we note the value of the specific gravity or density of the gas and the importance of the factor in the flow formula.

Effect of Higher Pressure

The density of the gas may be increased through additional pressure and thus forcing a given weight of gas to occupy less volume. Under higher pressures more gas is packed in a given volume and the weight per cubic foot of the gas is increased.

The effect of higher pressure, then, is to do the same work with less velocity. This is comparable to the vapor of 1.5 specific gravity. For instance, a gas with 0.75 specific gravity (about equal to 0.056 pounds per cubic foot at atmospheric conditions) would under two atmospheric pressures, 30 pounds absolute, have a density of 0.112 pounds per cubic foot. Air at atmospheric pressure weighs about .076 pounds per cubic foot. Therefore this gas of 0.75 specific gravity under 30 pounds absolute pressure with any velocity will produce the same differential as a vapor of 1.5 specific gravity under atmospheric pressure flowing with the same velocity.

Temperature alters the density of the gas in the same manner as pressure but to a much less degree. A standard cubic foot of gas at 60° F., of 0.75 specific gravity and .056 pounds per cubic foot when heated to 120° F. will occupy a space of 1.115 cubic feet and have a density of 0.502 pounds per cubic foot. Therefore an increase of temperature will increase the velocity of the gas to maintain the same differential.

Now that the orifice meter performance has been related to work (velocity and weight), it is necessary to study the coefficient to find how the volume is corrected for these factors. The basic formula for orifice meter measurement from the energy relations is

$$Q = 19.64\ Ed^2\ \sqrt{2gH}.$$

This formula corrected for gas measurement by applying the proper factors for the quantity, H (head in feet) to produce the h (head in inches of water differential) at flow conditions:

$$H = \frac{h}{12} \times \frac{62.37}{.08073 \times G} \times \frac{14.7}{P} \times T$$

Q = Rate of flow in cubic feet per hour.

E = Efficiency, related primarily to $\frac{d}{D}$ ratio and experimentally determined.

Corrected formula:

$$Q = 218.44\ Ed^2 \frac{P}{P_b} \times \frac{Tb}{T} \sqrt{\frac{hT}{PG}}$$

In the above formula, the expression $\sqrt{\frac{hT}{PG}}$ represents the effect upon measurement of the individual factors on the velocity of the flowing gas.

The expression $\left(\frac{P}{P_b} \times \frac{Tb}{T}\right)$ represents the effect upon measurement of the gas flows, by which the flow at line conditions is reduced to standard conditions.

The factor, d^2, represents the relationship of the orifice size to the volume of flow.

The above factors represent the basic formula for orifice-meter measurement. By extensive experimental investigation other factors have been found to influence the results.

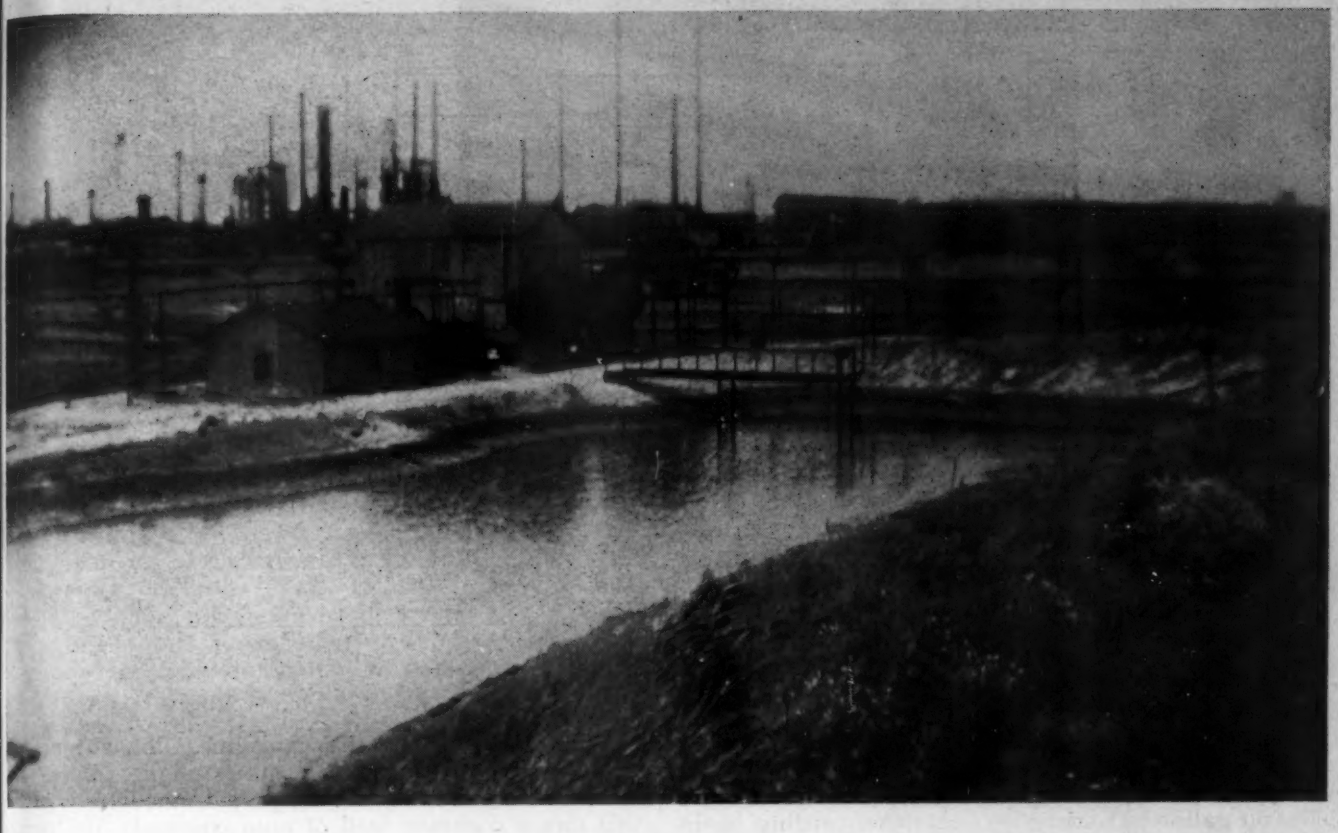
Reynolds Number

One of these is the viscosity of the gas being metered. Since Reynolds was one of the early investigators in velocity and characteristics of pipeline flow, this meter factor is known as the Reynolds number factor.

Another factor is known as the expansion factor. It was mentioned earlier in the paper that there was a decrease of pressure to produce the differential flow pressure that causes the gas downstream of the orifice to expand and be less dense than the gas upstream of the orifice plate. The density of the gas either upstream or downstream is not the true density of the gas passing through the orifice. In cases of high-pressure-gas measurement or where the differential pressure is a small proportion to the actual static pressure, this expansion is small and the correction factor is consequently of minor importance. Under high-vacuum conditions of measurement, this expansion is more real and in extreme cases may amount to large percentage factors. An example may be assumed at 26-inch mercury vacuum. This is 54.8-inch water absolute pressure. If this were downstream pressure and a differential of 10 inches of water existed across the orifice plate a change of the gas from 64.8 inches to 54.8 inches would cause a change of 18.3 percent in the density of the gas.

The last factor that is discussed here is the supercompressibility factor. This factor corrects for the deviation of natural gases to the laws of ideal gases. The laws of perfect gases state that the density of a gas is inversely proportional to the absolute temperature and directly proportional to the absolute pressure. This deviation has been found experimentally to vary with the different gases over the range of operating conditions. This variation differs with the composition of the gas as well as pressures and temperatures.

Fundamentally, the orifice meter is an instrument of sound engineering principle. Properly installed and operated, it will give service and accurate results.



Talco Refinery Trade-Waste Treating Purifies Water for Cooling

C. G. ROOK, JR., Water Chemist, Talco Asphalt and Refining Division
Southport Petroleum Company of Delaware

ONE of the greatest and most common problems confronted in oil refining is proper disposal of trade wastes. As a general rule the waste is a mixture of oil and water. The greater bulk of the oil is easy enough to separate from the water by means of a conventional oil trap, but the question arises "what can we do with the water?"

Usually a refinery waste water contains certain quantities of emulsified oils, sulphur compounds absorbed from contact with oil, caustic from treating plants, ground spillage, wash water from various units and numerous other contaminants resulting in a high-alkaline, turbid and offensive water. If a water of this nature be allowed to enter a stream there will certainly be a degree of pollution. Indefinite storage capacity would have to be provided to retain all the waste water from a plant. The waste water is certainly unfit for industrial purposes in its present condition. Since the water, as is, is unfit to enter a public stream, cannot be reused in the plant and cannot be indefinitely stored there is only one solution. Rid the objectionable qualities in the water by removing the oil in emulsion, reducing the alkalinity to near the neutral point, precipitate out the sulphides, clarify and deodorize. As a result there is a conversion of a worthless water to a suitable cooling water.

The problem of waste water disposal confronted Talco Asphalt and Refining Division at Mt. Pleasant, Texas, until January, 1945. This plant saw the advantage of curbing its trade waste for two reasons: to minimize pollution of a public stream, and to have a supply of cooling water during the dry season.

A water consultant was called upon to formulate a procedure of treating. After analysis of the disposal water, this chemical procedure was outlined:

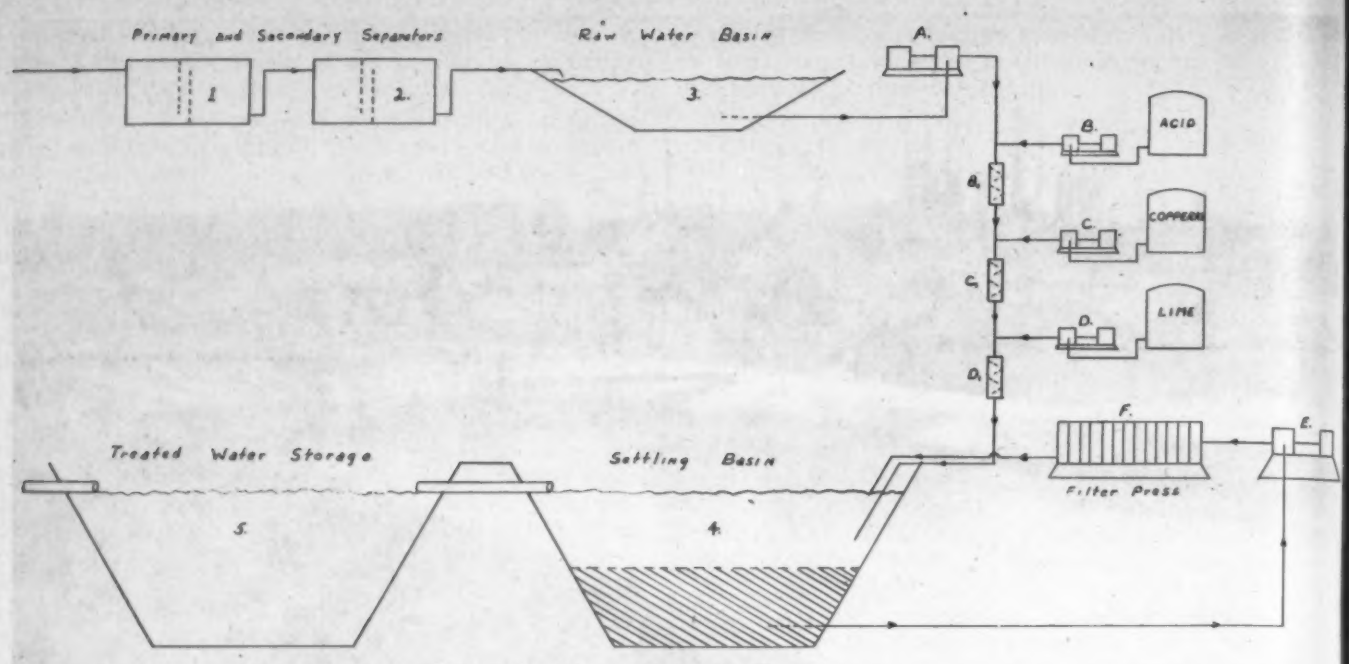
The water was to be neutralized to 7.0 pH with sulphuric acid. This treatment served two purposes. It broke out the oil in emulsion as well as neutralizing the water.

After neutralization with the sulphuric acid, an iron compound was introduced. In this case it was copperas or ferrous sulphate. The purpose of the iron is to precipitate the sulphides and to affix the water for ferric hydroxide flocculation for the removal of turbidity.

After introduction of the copperas a suitable amount of chlorinated lime is introduced. Enough to precipitate the iron as ferric hydroxide and to adjust the pH of the finished water to 8.0. Chlorinated lime is used because it not only oxidized the ferrous ion rapidly but it has a great odor-removing quality.

The floc thus formed by the combination of the copperas and the chlorinated lime enmeshes the suspended matter and oil in emulsion, and settles rapidly, leaving a clear, odor-free water.

Plans were drawn and construction began on the water disposal plant during August, 1944. By December it was completed and operation was started.



Flow diagram of water-treating plant

Referring to the accompanying drawing, the plant consists of (1) primary oil separator, (2) secondary oil separator, (3) raw-water earthern storage basin of 300,000 gallons capacity, (4) earthern settling basin of 2,500,000 gallons capacity, (5) earthern treated-water storage basin of 2,500,000 gallons capacity, (A) 350 g.p.m. single-stage centrifugal pump to pump water from raw-water basin to settling basin, (B) feeder for proportioning 10 percent sulphuric acid, (C) (D) chemical proportioning pumps for 20 percent copperas solution and 20 percent chlorinated lime slurry, (B_1) (C_1) (D_1) mixers, (E) 250 g.p.m. two-stage centrifugal pump and (F) one-ton filter press.

All the waste, water and oil bearing is conveyed by a common sewer to the primary and secondary separators. All the free oil is trapped in these separators, skimmed off, and pumped back to the refinery slop tank for re-refining. The effluent from the separators flows into the raw-water storage basin where it awaits treatment.

The raw water is pumped from the storage basin to the earthen settling basin. Enroute the water is neutralized by a constant supply of dilute sulphuric acid proportioned into the water line. The water-acid mixture passes through a mixer eight inches in diameter and four feet in length. Immediately after this mix a constant feed of approximately 700 parts per million copperas solution is introduced into the water line. The water-acid-iron mixture passes through a second mixer of the same dimension. After the second mix a sufficient amount of chlorinated lime slurry is introduced to the water which passes through a third mixer. Immediately upon the addition of the chlorinated lime a ferric hydroxide floc is formed. After the third mix the water and floc are discharged into the earthen settling basin. The floc immediately begins to settle, leaving a clear and odor-free water to overflow into the treated-water storage basin.

After several weeks of operation, an appreciable volume of floc accumulates in the settling basin. This is drawn out by means of a two-stage centrifugal pump and discharged through a filter press.

The treated water stored in the earthen pit is used for cooling-tower makeup. The excess is allowed to overflow into a public stream now free of oil and contaminants.

Settling basin and treated water storage

Compressed AIR

Refinery Production And Maintenance Tool

ED. C. POWERS
Compressed Air Institute

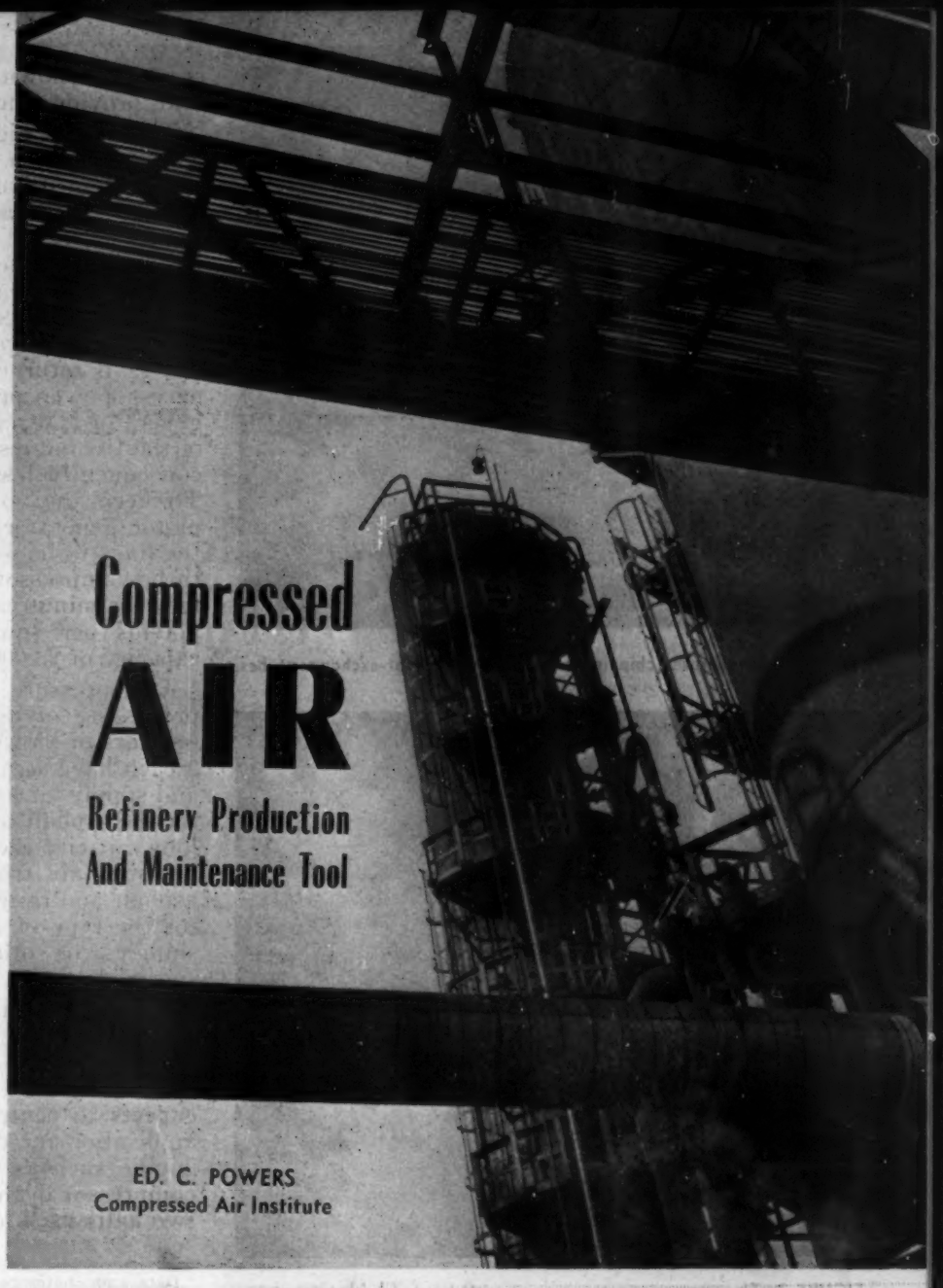


FIGURE 1. The dozens of small lines overhead carry compressed air for instrument control.

STANDING outside the instrument house for a new aviation gasoline plant at one of the largest Mid-West refineries, an observer can see overhead a network of small lines leading from the control center (Figure 1). Eventually these lines, each one carrying compressed air, fan out to different parts of the plant where extremely close and sensitive response to instruments controlling some step in the process is required.

This is one of the delicate assignments for compressed air. It also can be found at work on rugged jobs of hammering, hoisting, drilling and other maintenance work. And again it is found functioning in production processes. It is the unusual variety of work performed with compressed air that has won recognition for its versatility. Some of these applications are cited.

In the boiler shop, one of the uses for air-operated tools is illustrated in Figure 2. Here a worker is backing out a heat-exchanger tube with a chipping hammer, because that is the quick way to do it. Preparation to brush the interior of a tube is shown in Figure 3. The worker is using the same air motor for the brush that was just previously used for drilling out the clogged tube. The same air motor again operates the tube roller, see Figure 4, which flares the ends of the tubes to keep them in place. Pressure expands the tube roller after it is inside the tube while another part of the tool, also operated by air, hammers out the flare.

These heat-exchanger tubes come into the shop for cleaning or replacement in bundles of 50 up to 700. It is a maintenance job requiring powerful and easily handled tools which will do the work quickly and absorb the burden rather than tire the men at this constant job. The same requirements exist on the heavier task of cleaning out coke formed in the big tubes up in the towers. Drilling and tube rolling there is done with somewhat similar, but larger, air-operated tools.

A corner view of the refinery's tool room, Figure 5, suggests the many other uses for compressed-air-operated tools in the daily maintenance work. Impact wrenches, grinders, chipping hammers, riveting hammers and other equipment is shown. The picture was taken during the day when most of the air-operated equipment was out on caulking, riveting tank plates and similar work at the refinery, which is served by several miles of utility air lines so that air outlets are available in all areas.

The utility lines deliver compressed air at approximately 100 pounds pressure per square inch. Equipment, other than the tools mentioned, using this air include air-operated positioners for welding work, sand blast for cleaning towers before welding, and air hoists, such as shown in Figure 6, to deliver castings or whatever parts or materials are needed by work crews high above the ground. Asphalt lines are blown out with compressed air and condensers are cleaned with it.

A two-stage reciprocating type air compressor, and a gas engine converted into a compressor, supply the utility air for the lower area of the refinery. Compressed air for utility lines in the upper area of the refinery is supplied by the two large air compressors shown in Figure 7.

The mentioned applications for high-pressure air off the utility lines do not represent all the ways compressed air is serving the refinery. A noteworthy example of other applications is in the big catalytic crackers. A turbo compressor unit for supplying air to burn off the carbon from the catalyst of a 6-case

FIGURE 2. Air-operated chipping hammer removes heat-exchanger tubes.

FIGURE 3. The same air motor is used with brush for cleaning tubes.

FIGURE 4. Tube roller operated by air puts flare on exchanger tubes.

cracker is shown in Figure 8. A similar, but smaller unit, provides the air for a 3-case cracker.

The unit in Figure 8 is started by a steam turbine. The combustion products coming off the cases are returned to drive the gas turbine, entering the turbine at 900° F. and coming out at 600 degrees. This energy from the cases permits a manual shut-off of the steam turbine after the process is under way. The process is intermittent, air entering a new case every 10 minutes. Since the air going into a new case encounters more carbon at first, an excess amount of energy is returned to the big turbine. To absorb the excess power produced, it is directed to a motor generator and returned to the lines. Toward the end of the 10 minutes, there is less carbon in the case and consequently less energy going to the big turbine. To keep the compressor at a constant speed the motor generator at this point delivers power from the lines to boost power needed by the turbine. The turbo-compressor unit has a capacity of 40,000 cubic feet per minute and produces air at a pressure of 45 pounds per square inch. The smaller unit has a capacity of 23,000 cubic feet per minute.

Low-pressure air finds another application in the processing of asphalt. Three rotary type air compressors or blowers such as the one shown in Figure 9 each have a capacity of 1600 cubic feet per minute and supply air at 40 pounds per square inch pressure for the asphalt oxidizers. Twelve tanks of 50,000 gallons capacity each are used in this process. The low-pressure air from the three blowers oxidizes the asphalt and raises the melting point to specifications for the type of asphalt wanted—paving, cold patch, shingles or others with varying melting points specified.

Instrument air is obtained from locomotive-type compressors scattered throughout the refinery, although some of these compressors are grouped together for better maintenance and the refinery expects to centralize others in the future. Another application for compressed air is for starting a gas engine such as shown in Figure 10. The small air compressor in the foreground of the picture is one of two units used for this purpose.

Data and photos for this article were obtained by the Compressed Air Institute through the courtesy of Standard Oil Company of Ohio.

FIGURE 5. This tool room shows the variety of air tools in daily use.

FIGURE 6. Whenever men are at work high aboveground, air hoists lift materials to them, from the heaviest castings to the lighter tools and supplies.

FIGURE 7. The water pumping station. The two compressors in the foreground of this picture supply part of utility air used in refinery.

FIGURE 8 (Right). Turbo-compressor unit used to burn carbon from catalyst. At left is the motor generator, next is the gear reducer; the compressor is in the center, and at the right is the turbine. Compressed air at 45 pounds per square inch pressure and 450° F. goes to the cases through the pipe at the left. The air returns at 900 degrees through the pipe at right and goes through turbine, coming out below at 600 degrees.

FIGURE 9. One of three rotary-type air compressors which supply twelve 50,000-gallon tanks with air at 40 pounds pressure—for oxidizing asphalt.

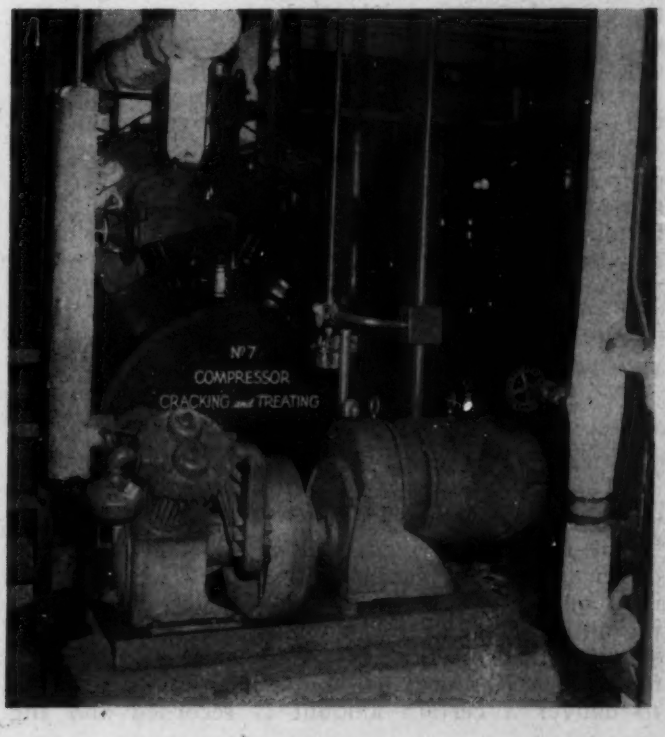


FIGURE 10 (Below). The small air compressor in the foreground is used to start the large air compressor that is shown in the background.

Pressure Viscosity and Consistency of Greases

ALBERT E. HICKEL, Consulting Lubricating Engineer

PRESSURE viscosity of greases has been advocated recently by several investigators, although this method of testing and controlling greases has been successfully used by one company for the past twelve years, especially on semi-fluid and soft greases.

Pressure viscosity of greases is an exact duplicate of the Saybolt viscosity as applied to oils, but as the name implies, pressure of some sort is necessary, either with air from a constant-pressure tank or by a hydraulic fluid-pressure system operated by means of a geared pump.

The pressure viscosity can be taken at various temperatures with this instrument. It is equipped with a Standard Saybolt orifice as described later and is contained in a cabinet that can be cooled or heated to the desired temperatures. The Saybolt "Furol" orifice can also be used where a very heavy grease is to be tested at low temperatures, and when the results obtained are multiplied by 10, the answer is the same as the regular pressure viscosity taken with the Standard Saybolt orifice.

It has been found that with semi-fluid greases, the actual pressure viscosity is within 10 percent (low) of the true Saybolt viscosity, while with heavy oils the results obtained are within 4 percent (low) of the true Saybolt viscosity.

Greases above semi-fluid consistencies and up to wheelbearing greases or heavier, are closer to the actual or true pressure viscosity without any additions or deductions, but the temperatures of the greases, as well as the air temperature in the cabinet must be constant for 10 to 15 minutes so that both thermometers are exactly the same, a careful operator can check and duplicate results every time.

The tests shown herewith were made with Sinclair Refining Company's pressure viscosimeter, designed by Carl L. Knopf, staff engineer, and the factors obtained were calculated from Poiseuille's equation:

$$\text{P.V.} = \frac{K - P}{R} = \frac{K \times P \times T}{\text{rate}} =$$

$$\frac{\text{Constant} \times \text{Pressure} \times \text{Time}}{\text{grams}} = \frac{525 \times 50 \times 2.0}{56} = 937$$

K — represents the factor (525)
P — pressure per square inch
T — time in seconds
Rate — total grams delivered

The factor is derived from the flow rate and the dimensions of the capillary or Saybolt orifice. This is a constant. The pressure used will vary depending on the grade of grease tested, i. e. the least pressure for the soft greases and the greater pressures for the heavier greases. Time in seconds required to deliver a certain amount is recorded and the amount delivered is weighed. The results obtained are then calculated as shown in specimen formula to obtain the correct pressure viscosity of the grease.

By dividing the seconds (time) into the total grams delivered, the shear-rate of grams per second were obtained and plotted against the pressure viscosity as shown in Chart I. For example, on the original of No. 1061 grease, 56 grams divided by 2 seconds = 28 grams per second with 50 pounds pressure and on the original of No. 1061 A.A. grease: 44 grams divided by 2 seconds = 22 grams per second with 40 pounds pressure.

The instrument consists of a cylinder nickeled-steel tube for the lubricant sample, mounted in an insulated cabinet which can be maintained at a constant temperature within a range from — 25° F. to 225° F. The top cap of the tube communicates with a constant-pressure air tank. The bottom of the tube is concave and holds the Standard Saybolt orifice. Needle valves control the pressure in the tank and a stop-and-waste cock enblaes the operator to apply pressure to or release it from the tube containing the grease.

A hinged cover at the bottom of the tube, covering the orifice is operated by a lever and rod to release the lubricant into the receiver cup. This lever is located on the outside of the cabinet so that the operator will not have to open the cabinet during the test.

The best method to obtain the correct pressure-viscosity of a grease and its increase in consistency after heating in the oven for 50 hours at 210° F. temperature, is to take four or five pressure readings at a selected temperature, and plot them as in Chart I.

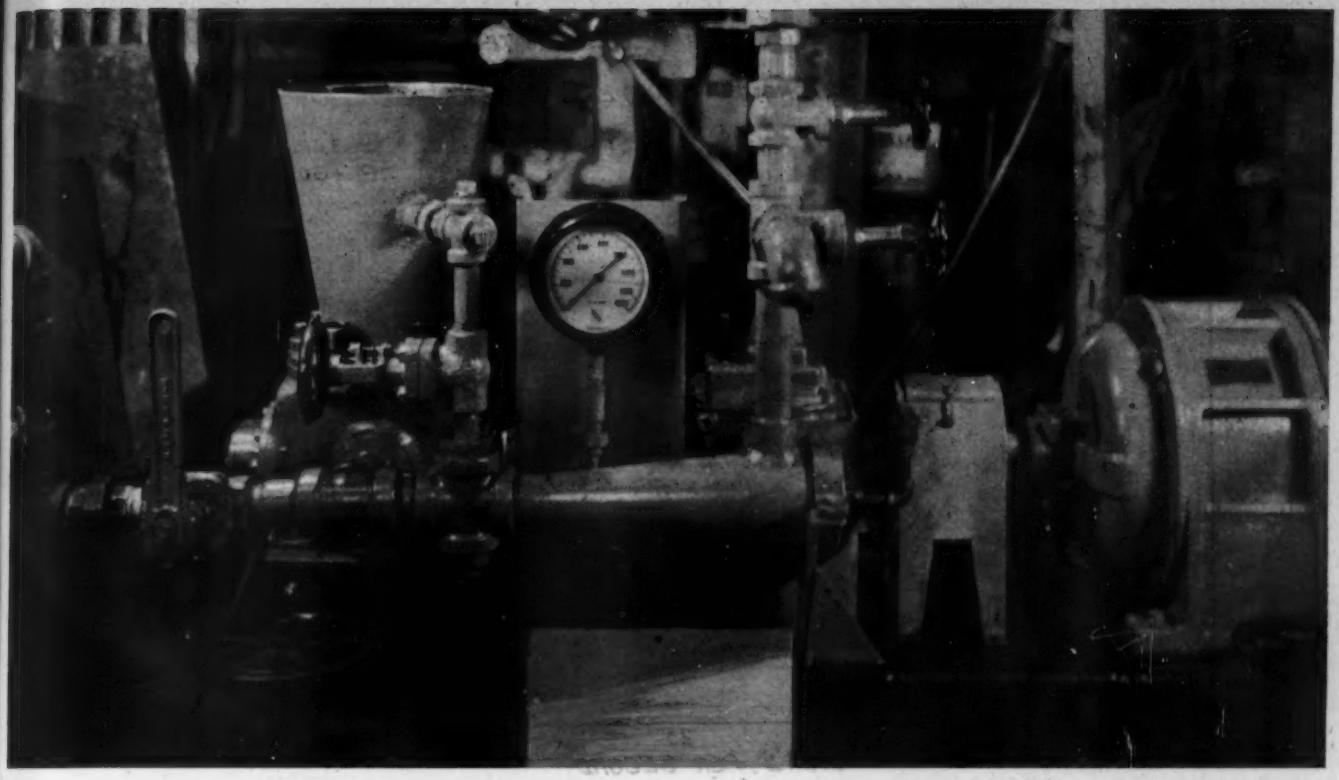
A new low-torque, low-temperature soda-soap grease, similar to an A. N. — G3 grease was used. As far as is known, this is the only transparent short-shear soda-soap grease made in the regular steam kettle.

It can be made of various consistencies, from an A.S.T.M. grade 0 to a grade 5. The lighter grades are bright, clear, amber-colored greases and have an unusual greasy film, more on the order of a heavy calcium soap grease.

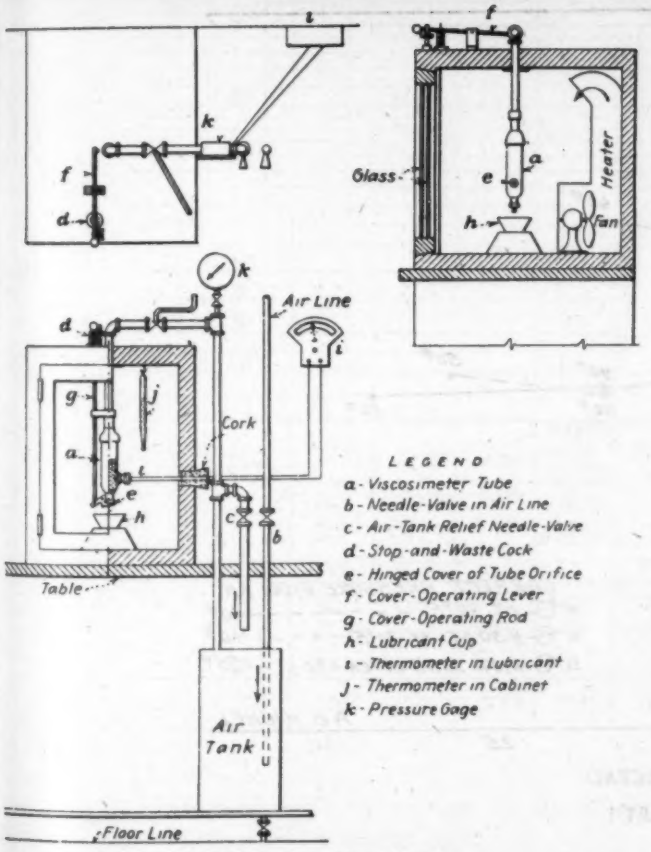
Both greases shown in charts were homogenized products and then forced through a special milling machine and a conical tube at about 95° F. to 100° F. temperature. The clearance in the tube was set at .005-inch.

The tube containing a grooved core can be adjusted to any clearance down to .001-inch. It is attached to a standard pump assembly as shown in accompanying photograph.

By using a 14-inch diameter supply tank instead of cone-shaped tank on top of the pump, a follower plate can be used to help the feeding of the greases



Pump Assembly for Testing Grease



Sinclair Pressure Viscosimeter

A cylindrical nickeled-steel tube, *a*, for the lubricant sample is mounted in an insulated cabinet which can be maintained at a constant temperature within a range from —25 to +225° F. The top cap of the tube communicates with a constant-pressure air-tank below the cabinet. Needle-valves, *b* and *c*, control the pressure in the tank, and a stop-and-waste cock, *d*, enables the operator to apply pressure to or release it from the tube *a*. A hinged cover, *e*, at the bottom of the tube is operated by a lever, *f*, and a rod *g*, to release lubricant into the lubricant cup, *h*.

into the pump, it also will prevent air from getting into the pump, and the grease comes out perfectly clear and free from air. This method of finishing a grease also assists in preventing excessive bleeding of the finished product.

The greace No. 1061 A. A. shows the following tests:

A.S.T.M. Cone Penetration unworked	305
A.S.M.E. Cone, worked 60 Str.	309
M. P. (Dropping)	306° F.
Bleeding test (50 hrs. at 210° F.)	3%
Evaporation (50 hrs. at 210° F.)	10%

Chart I

Chart I shows a shear-rate in grams per second, plotted against pressure viscosity. Four to five pressures for each sample are required to analyze the correct reading, the lowest pressure-viscosity is the correct reading.

The three curves in Chart No. I represent:

The original sample
The original, plus 30 strokes (A.S.T.M. Worker)
The original, after the oven heating, plus 30 strokes.

The pressure-viscosity ratio of the original sample at + 70° F. and that of the sample after the oven at — 68° F. should not be over 1.25 to 1.50 times as heavy, otherwise, it will not meet the 50 percent increase allowed in R. P. M. per minute over the original at — 68° F.

The 30 strokes in the A.S.T.M. worker represents the spinning of the charged bearing before torque tests are made.

Chart I shows a pressure-viscosity on the original sample No. 1061 at 40 pounds pressure of 840 as against 1200 after oven with 55 pounds pressure or a ratio of 1.4.

Batch No. 1061 A. A. shows the same ratio with a correct pressure of 40 pounds on the original and 55 pounds pressure on the sample after heating in the oven. The heavier greases take more pressure

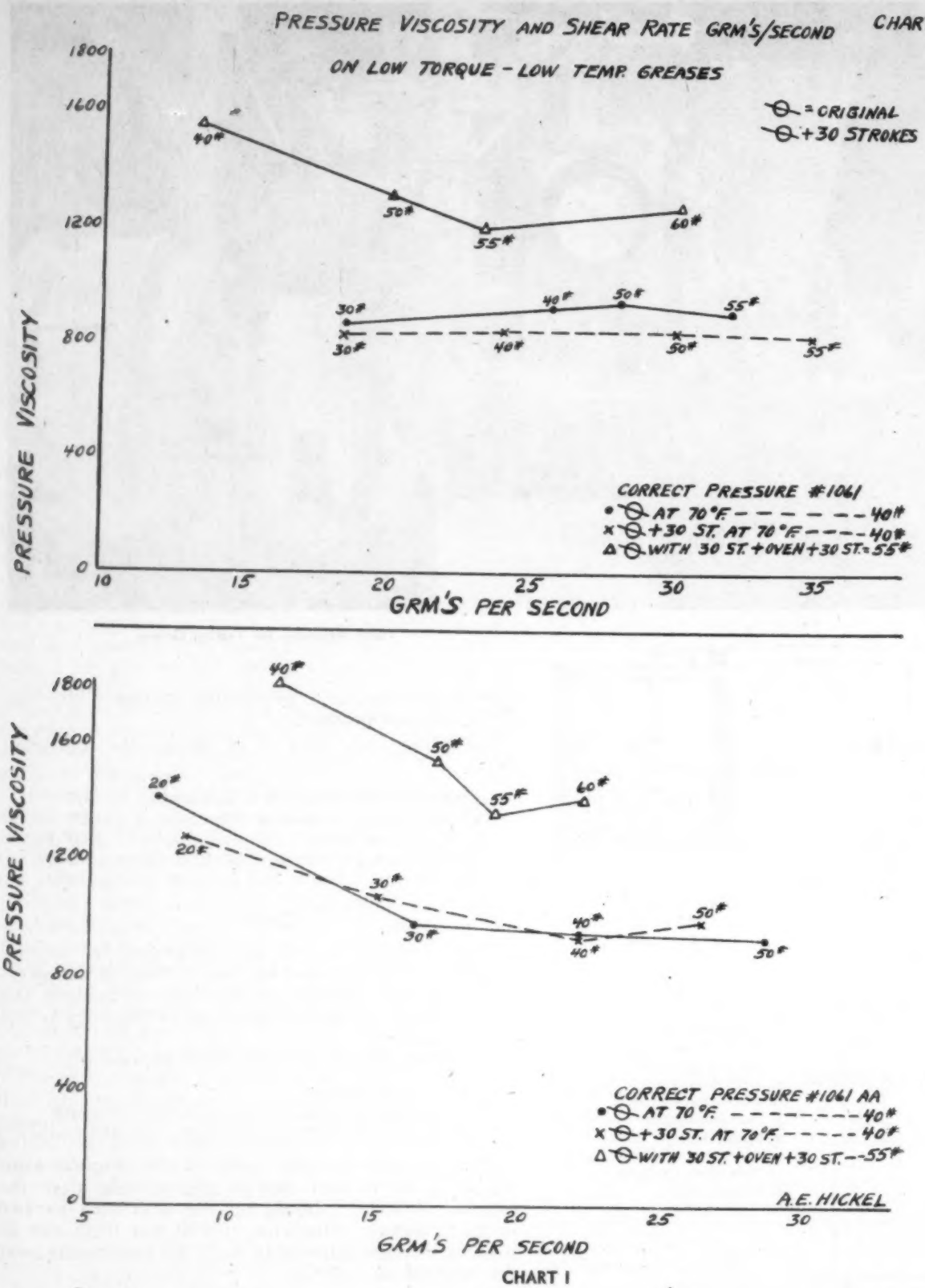

PRESSURE VISCOSITY AND SHEAR RATE GRM'S/SECOND
CHART I
ON LOW TORQUE - LOW TEMP. GREASES
= ORIGINAL
+30 STROKES
PRESSURE VISCOSITY
GRM'S PER SECOND
CORRECT PRESSURE #1061
AT 70°F. ---------- 40#
+30 ST. AT 70°F. ---------- 40#
WITH 30 ST. + OVEN + 30 ST. = 55#
CORRECT PRESSURE #1061 AA
AT 70°F. ---------- 40#
+30 ST. AT 70°F. ---------- 40#
WITH 30 ST. + OVEN + 30 ST. = 55#
A.E. HICKEL

CHART I

depending on the viscosity of the oil and percentage of soap in the grease.

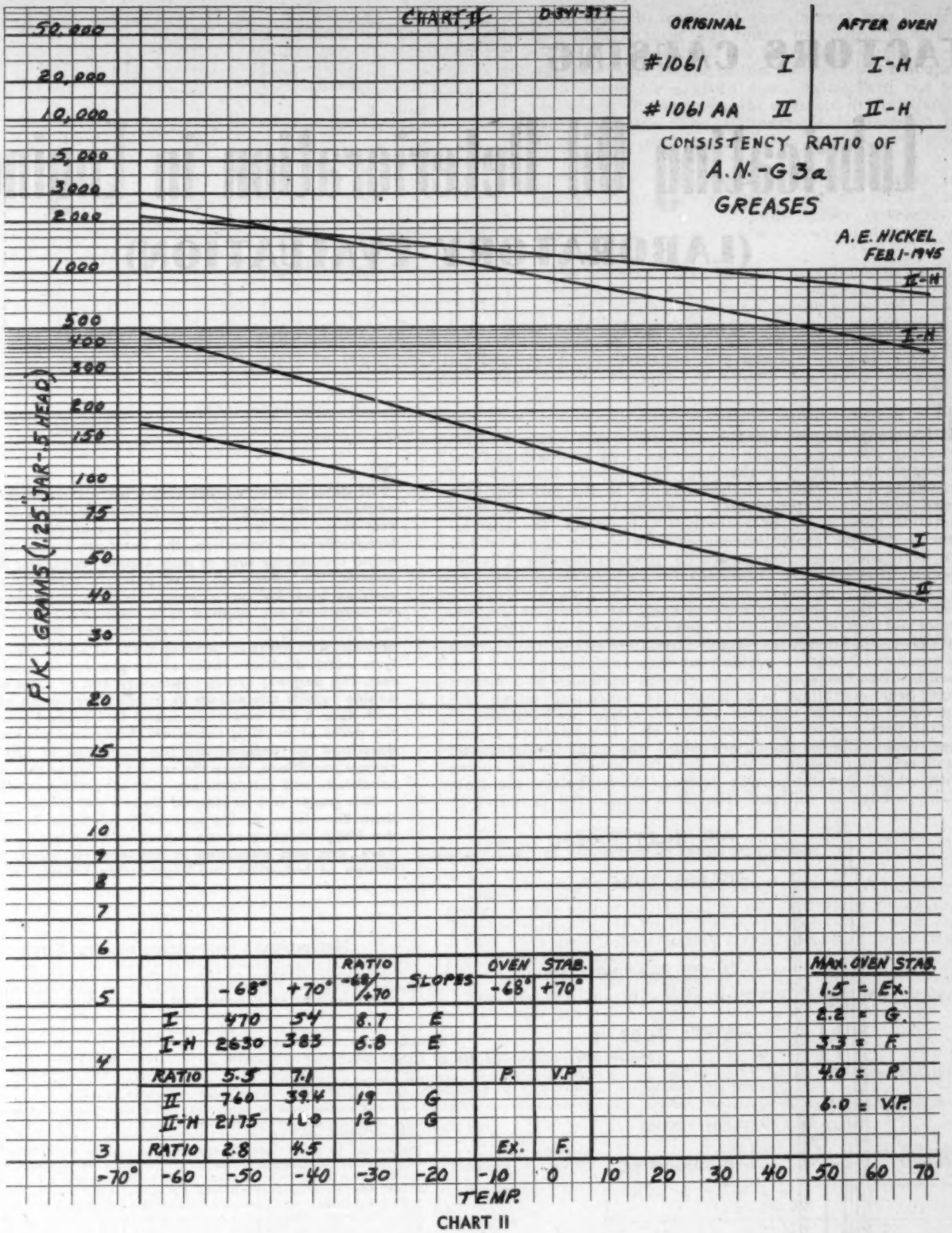
Chart II

Chart II shows relation of consistency, which is made in a 4-ounce pour jar with a small plunger ¼-inch diameter face and having a ⅛-inch diameter shaft, first, on the original grease at + 70° F. as against consistency increase after heating 50 hours at 210° F. also taken at + 70° F.

The same procedure is followed on the original at — 68° F. and after heating in the oven, again at — 68° F.

In testing the heavier greases for increase in consistency, an insulated 2-ounce metal jar is more suitable, 1¼ by 2½-inches deep, otherwise the heavy grease at sub-zero temperatures would break the glass pour jar.

A Consadometer or small hydraulic press can be used to indicate the resistance, which is shown on a



	-68°	+70°	RATIO -68°/+70°	SLOPES	OVEN -68°	STAB. +70°
I	470	54	8.7	E		
I-H	2630	383	6.8	E		
RATIO	5.5	7.1			P.	V.P
II	760	39.4	19	G		
II-H	2175	170	12	G		
RATIO	2.8	4.5			EX.	F.

MAX. OVEN STAB.
1.5 = Ex.
2.2 = G.
3.3 = F.
4.0 = P.
6.0 = V.P.

CHART II

dial and is then converted to grams. A speed of 9 inches per minute travel is about right.

The curves 1 and 1-H of batch No. 1061 show steeper slopes than curves 2 and 2-H (Batch No. 1061 A. A.). The consistency ratio of 2.8 at — 68° F. of original and after oven, is considered very good for this type of soda-soap grease because there is a certain loss of the low-viscosity oil at high oven temperature and because the grease is just on the alkali side.

A lower consistency ratio of about 1.5 may be obtained with other types of salts or the soda-soap grease could be just on the netural side to obtain the same results.

Homogenizing (heating in the kettle or in a tubular conditioning tank) at 140-150° F. temperature greatly assists in absorbing any free sodium that may be present in the grease, and a final milling, by means of a special pump as described, will produce a slight increase in consistency but should now be perfectly stable under any heat encountered in actual service. If the increase in consistency due to milling is too great, sometimes as much as one A.S.T.M. grade with certain types of greases, the grease has not been homogenized long enough.

FACTORS CAUSING

Lubricating Oil Deterioration in Engines

(LABORATORY EVALUATION)

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THE deterioration of lubricating oil in internal-combustion engines is due largely to oxidation reactions. It is shown that these reactions are primarily catalytic at the engine temperatures in question, the catalysts being metals and metal compounds such as iron, copper, lead, and their compounds. The effects of other possible catalytic materials, such as blow-by gas components, are considered. These observations are applied to a laboratory test procedure for evaluating the service stability of oils in which an attempt was made to develop a set of conditions and catalysts which duplicate those of the present Chevrolet engine test. The degrees of reproducibility and of correlation with engine results are shown in detail. Correlation of the test with four B oils has been found to be good except upon the point of bearing corrosion. Additional procedures are described for determining the tolerance of oils to more severe conditions, since the results indicated that the above conditions and catalysts are not universally suitable.

This paper was presented before the Division of Petroleum Chemistry, Symposium on Bench-Scale Techniques, at the 108th Meeting of the American Chemical Society, New York, and was published in the May 15, 1945, Analytical Edition of Industrial and Engineering Chemistry.

THE complexity of factors causing the deterioration of lubricating oils in an engine has necessitated a widespread use of engine tests for oil evaluation. The obvious desirability of providing a laboratory method has led to the proposal of a large number of procedures. Excellent reviews of these methods have appeared recently.[20,21] However, the correlation of the laboratory procedures with engine operation has not been adequately demonstrated, possibly because it is but recently that standard engine tests have been developed.

The results of many investigations,[5,6,9-22] as well as the work described herein, provide a basis for understanding the important factors causing the deterioration of oil. The utilization of this knowledge should ultimately enable the chemist to conduct laboratory evaluations with confidence. As a step in this direction some of the relevant variables and factors have been combined in a laboratory procedure which will correlate in most respects with a certain well-established engine performance for a series of oils. The selection of factors responsible for the deterioration was made to correspond as closely as possible, in a quantitative fashion, to the engine with which correlation was desired. Nevertheless, the state of knowledge is still such that it is considered desirable to augment the results of this procedure with one or more "tolerance" tests in which the resistance of the oil to possible increases in the severity of certain factors can be observed. This procedure often is very desirable in the study of activities.

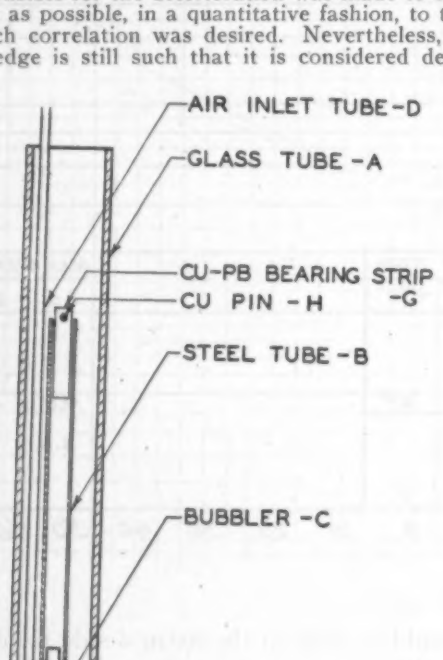

FIGURE 1
Oil Deterioration Cell for Suspending Solids

* Present address, Plastics Division, E. I. du Pont de Nemours & Company, Wilmington, Delaware.

Mechanical Construction of Test Equipment

A schematic diagram of the apparatus used in this investigation is shown in Figure 1. A 160-cc. sample of oil was used in a glass tube, *A*, 45 mm. in outside diameter and 42 cm. long. A piece of steel tubing, *B*, 1.3 cm. in outside diameter by 1 cm. in inside diameter and 14 cm. long was centered in the glass tube and was held in place on the glass support, *C*, attached to the air-inlet tube, *D*. This support was spaced from the bottom of tube *A* by 2-mm. glass tabs to allow oil and suspended solids to pass into the support and up the air lift. The air-inlet tube and steel tube supports also may be made of steel, which is more rugged but a little more difficult to clean.

In the upper end of steel tube *B* a flat piece of bearing metal, *G*, was inserted and was held in place by a copper pin, *H*. The size of each of these two pieces was adjusted to give the ratio of corresponding metal to oil volume found in the engine with which comparison was sought. Numerous other arrangements have been tested but that shown was preferred. A glass wool plug was placed in the top of the glass tube to minimize oil loss by splashing.

The assembly was placed in a thermostat which in the authors' case comprised an electrically heated aluminum block[16] with 14 holes for the test units. It weighed 185 pounds, and was 48.4 cm. (19 inches) long, 24.5 cm. (9.625 inches) wide, and 29.6 cm. (11.625 inches) high. The electrical energy consumption ran 6.33 kw.-hr. per 36-hour test. Air under constant pressure was passed through a porous clay filter to remove dust and then through concentrated sulfuric acid containing chromic acid to remove water and sulfur dioxide. The air rate was indicated by calibrated orifice-type flowmeters and was controlled by 0.6-cm. (0.25-inch) needle valves.

Operation of the Test

The glass parts were cleaned by the usual chromic acid method, rinsed, and dried. The steel and copper parts were washed with chloroform or methyl ethyl ketone, or both, and polished until bright with No. 925 emery cloth or steel wool. The steel tube was, in most cases, rotated for polishing purposes with a motor and chuck. New bearing pieces were used each time. The copper and bearing metal parts were weighed before and after the test to ascertain corrosion. After assembly with the oil in the test block, the oil was brought to temperature, the soluble catalyst added, the air flow started, and the lead bromide added immediately. This procedure required 0.5 to 1 hour, and the period before the air was started was not included in the recorded duration of the test.

A study of test conditions has been made and the following were

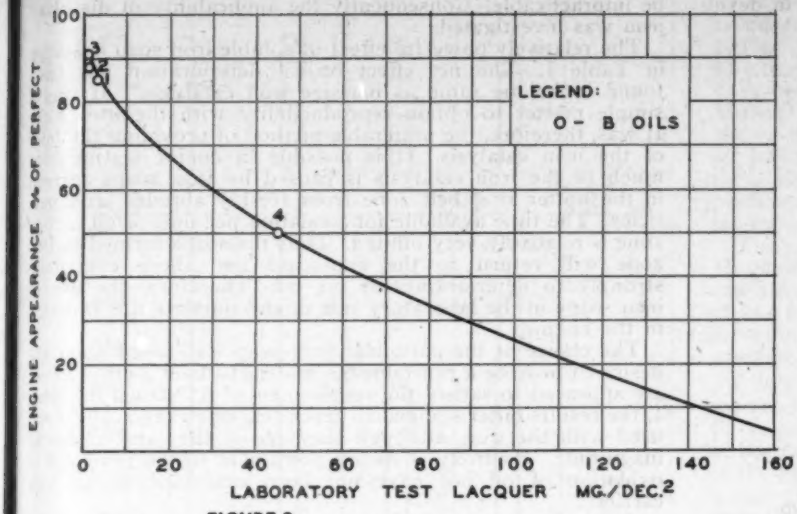

FIGURE 2
Conversion Chart of Lacquer to Engine Appearance

curve with the vertex at zero lacquer was chosen because this form was found to relate the actual weight of the lacquer to the visual rating on a single-cylinder engine piston. The weight of lacquer on a piston for a given visual rating will not be necessarily the same weight obtained in the laboratory procedure. The approximate relationship in Figure 2 is used in correlating engine tests with the laboratory procedure.

The copper and bearing metal pieces, after an oxidation test were scrubbed with chloroform or methyl ethyl ketone, or both, before reweighing. The change in weight was a rough indication of corrosion.

The used oil was sufficient in volume to enable determination of all the usual oil tests. The oil-insoluble sludge remaining in the glass tube was thought to be related to similar sludge deposits in engines. It was rated visually against color photographic standards and a scale ranging from F (worst) through A (best) has been used for recording.

used when correlation was desired for the *B* oils with the present "standard" Chevrolet test:

Temperature	280° F. for heavy-duty oils
Oil sample	160 cc.
Air flow rate	70 liters per hour
Time	36 hours
Catalysts	Steel, 100 sq. cm. (tube *B*, Figure 1)
	Copper, 1 sq. cm.
	Copper-lead bearing, 4.4 sq. cm.
	Ferric 2-ethyl hexoate, 0.012% as Fe_2O_3 in C. P. benzene
	Lead bromide, 0.1% as precipitated powder

The ferric 2-ethyl hexoate was prepared by reacting sodium 2-ethyl hexoate with ferric nitrate solution, followed by washing and decantation. The solution in benzene was prepared by Soxhlet extraction of the precipitate with benzene, followed by an analysis of the solution for iron. The 2-ethylhexoic acid was obtained from the Carbide and Carbon Chemicals Corporation.

The lead bromide was prepared by reacting calcium bromide in absolute alcohol (1 molar) with alcoholic lead acetate at 32° F. followed by filtering and washing with absolute ethanol. This was vacuum-dried to constant weight. The surface area (Emmett method) of the lead bromide was 1.0 sq. meter per gram.

At the close of the test the lacquer deposition on *B* (1 sq. dm. area) was determined as the difference in weights after washing with a light naphtha and scrubbing with chloroform, methyl ethyl ketone, or both. After each wash the tube was air-dried to constant weight.

Figure 2 shows a tentative relationship between the weight of lacquer as determined by this procedure and the visual rating system used in engine testing. The form for this

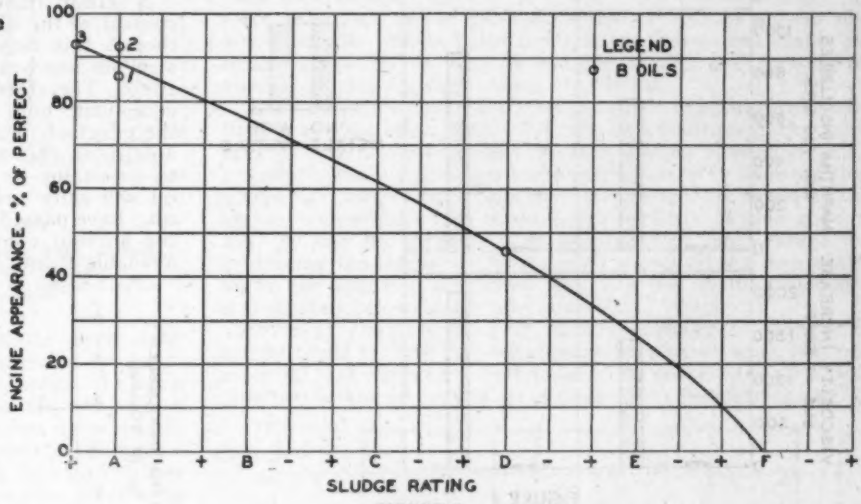

FIGURE 3
Conversion Chart of Appearance to Engine Appearance

Figure 3 shows a relationship between the visual ratings of sludge in the engine tests and in the laboratory procedure. The derivation of the curve was largely empirical from the B oils. It is used for correlating engine data with those from the laboratory procedure.

Development of the Test

The effects of the following variables on the deterioration

TABLE 1
Comparison of Ferric Soaps in the Laboratory Procedure

(Time, 36 hours. Temperature, 280° F. Air rate, 70 liters per hour. Metals, 10) sq. cm. of steel, 4.4 sq. cm. of Cu-Pb, 1.0 sq. cm. of Cu. Catalyst, 0.02% Fe_2O_3 as naphthenate, propionate, or 2-ethyl hexoate in benezene as specified. Oil 160 ml.)

	SOHIO LABORATORY TEST, FeO_3			36 Hours Chevrolet	SOHIO LABORATORY TEST, Fe_2O_3			36 Hours Chevrolet
	Naphthenate	as: 2-Ethyl hexoate	Propionate		Napythenate	as: 2-Ethyl hexoate	Propionate	
	OIL B-1				OIL B-2			
Lacquer, mg. per sq. dm.	2.6	0	0.9	....	3.2	0	1.1	....
Isopentane insolubles, mg. per 10 grams	150.7	201.6	12.9	130.4	0.1	2.8	2.0	57.3
Chloroform solubles, mg. per 10 grams	148.0	198.8	10.4	102.6	.....	.....	.....	17.6
Cu weight loss, mg	0.4	1.4	0.4	....	1.9	3.4	0.5	....
Cu-Pb weight loss, mg	16.5	23.5	9.0	9.3	12.7	19.3	19.3	32.0
Neutralization No.	1.33	2.06	0.75	2.40	3.07	1.64	1.93	5.41
Saponification No.	16.8	16.6	11.6	....	26.9	28.9	38.7	....
Viscosity increase, Saybolt, seconds at 100° F	460	669	230	489	1546	675	691	389
Sludge rating	B	B—	A+	....	B+	A	B	....
	OIL B-3				OIL B-4			
Lacquer, mg. per sq. dm.	1.9	0	1.1	....	52.7	31.4	26.1	....
Isopentane insolubles, mg. per 10 grams	4.0	2.8	4.4	39.7	623.5	732.5	491	235.6
Chloroform solubles, mg. per 10 grams	.....	.....	.....	8.1	620.0	731.3	462.0	216.6
Cu weight loss, mg	1.4	1.4	1.1	....	0.2	2.0	0.2	....
Cu-Pb weight loss, mg	13.2	5.2	6.0	8.0	10.5	9.3	6.0	3.12
Neutralization No.	0.83	0.53	0.33	1.36	3.82	4.09	1.87	4.99
Saponification No.	2.3	4.0	5.95	....	25.4	28.9	31.9	....
Viscosity increase, Saybolt, seconds at 100° F	35	20	34	86	5838	4740	1958	904
Sludge rating	A+	A+	A+	....	D	D	D	....

of oils in the laboratory apparatus were considered in developing this test:

1. Catalytic factors
2. Effect of blow-by materials
3. Temperature
4. Duration of test
5. Volume of oil
6. Rate of air flow
7. Procedure for addition of catalyst and oil

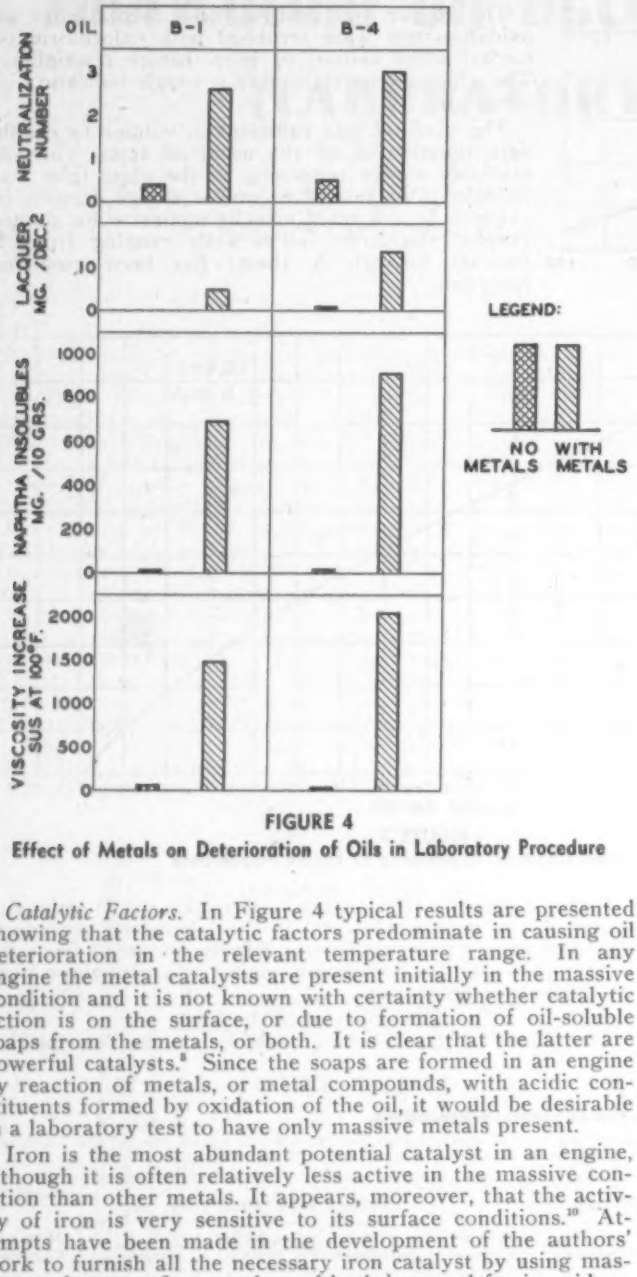

FIGURE 4
Effect of Metals on Deterioration of Oils in Laboratory Procedure

Catalytic Factors. In Figure 4 typical results are presented showing that the catalytic factors predominate in causing oil deterioration in the relevant temperature range. In any engine the metal catalysts are present initially in the massive condition and it is not known with certainty whether catalytic action is on the surface, or due to formation of oil-soluble soaps from the metals, or both. It is clear that the latter are powerful catalysts.[8] Since the soaps are formed in an engine by reaction of metals, or metal compounds, with acidic constituents formed by oxidation of the oil, it would be desirable in a laboratory test to have only massive metals present.

Iron is the most abundant potential catalyst in an engine, although it is often relatively less active in the massive condition than other metals. It appears, moreover, that the activity of iron is very sensitive to its surface conditions.[10] Attempts have been made in the development of the authors' work to furnish all the necessary iron catalyst by using massive surfaces, or fine powders of both iron and ferric oxide.

Figure 5 shows the relative effectiveness of the various forms of iron, including two methods of preparing the massive surfaces. One of these, electrocleaning, is a common method of cleaning engine parts between tests. Iron powder was the most effective type, and by using large quantities it was possible to obtain extensive deterioration in 36 hours, if the temperature of the test was 310° F. However, good correlation with engine results could not be obtained under these conditions and reproducibility was poor. Since the iron powder was prepared by reduction of the oxide with hydrogen, it was pyrophoric to a certain extent. This often led to considerable difficulty in handling. Finally attempts were made to prepare a composite catalyst containing all the principal active components occurring in the practice. However, if reasonable amounts of lead bromide, copper-lead, and copper were employed in the laboratory procedure and, in addition, sufficient iron were taken to increase the rate of oxidation to that of the engine, so large a quantity of massive iron—e.g., tubes, powder, wool—would be required as to be impracticable. Consequently the applicability of dissolved iron was investigated.

The relatively powerful effect of soluble iron soap is shown in Table 1. The net effect on oil deterioration has been found to be the same as massive iron catalysis.[10] It was a simple matter to obtain reproducibility with the iron soap. It was, therefore, the preferable method of providing the bulk of the iron catalysis. It is possible in engine testing that much of the iron catalysis is caused by iron soaps formed in the hotter ring belt zone from freshly abraded iron particles. The time available for oxidation per unit of oil in this zone is relatively very limited. Thus the soaps formed in this zone will return to the crankcase and there contribute strongly to deterioration of the oil. Therefore, the use of iron soaps in the laboratory test might simulate the situation in the engine.

The choice of the particular iron soap was based upon the desire to provide a reproducible material. Iron 2-ethyl hexoate appeared to satisfy the requirements. As shown in Table 1, the results differ somewhat depending upon the acid radical used with the iron, although they are of the same order of magnitude. Hydroxy acids are prominent in the products of oxidation of oil but have not been examined as an iron carrier.

A certain amount of iron catalysis may occur as a result of contact of the oil with the iron surface of the crankcase, although this may vary greatly between oils. Moreover, the steel surface was desired in order to determine lacquer deposition. Therefore some massive iron was retained in the test equipment, and Figure 6 shows, in the case of certain oils, the effect of omitting it. The amount of iron catalyst available in an engine under a given set of conditions is difficult to determine by direct measurement. Analysis of the used oil will show only what is left in solution; further amounts may have passed through and into the sludge, etc. Therefore, the amount contributing to the oil deterioration over that available from the massive iron in the test was determined

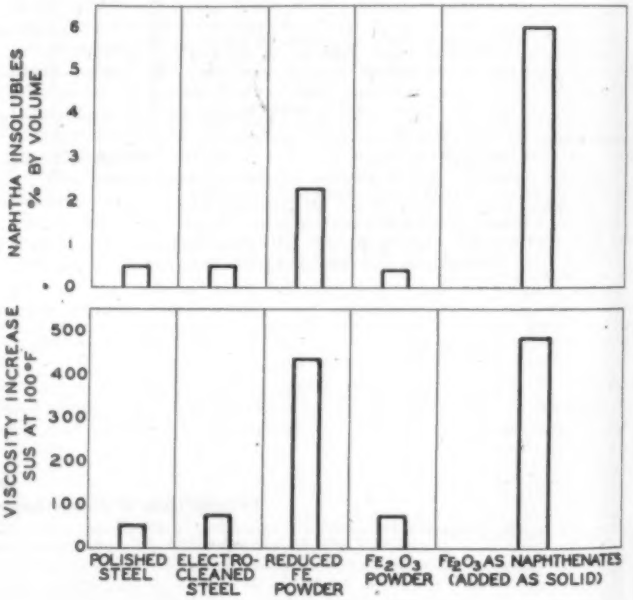

FIGURE 5
Effect of Various Types of Iron
Oil B-1. Temperature, 310° F. Air rate, 70 liters per hour. Time, 36 hours. Metals. Steel as specified. Cu, 1.0 sq. cm. Cu-Pb, 4.4 sq. cm.

by adding iron soaps until breakdown equivalent to that in the engine was obtained for a series of oils.

The catalytic effects of the copper and copper-lead bearing metal can both be supplied by the massive metal without resorting to the use of soluble salts. Figure 6 shows how each of these catalysts contributed to the deterioration of oil B-1. By omitting one catalytic factor at a time it was found that all the catalysts in the test except massive iron were active catalysts for the deterioration of the oil. With some oils, one of the catalysts may be more effective than the others but all these catalysts, at least, must be present to reproduce engine catalysis faithfully.

The other metal present in the Chevrolet engine in appreciable quantity is babbitt but this has been found by the authors to have no appreciable effect. While not present in the Chevrolet engine, aluminum has also been found by the authors and others to be without action.[8]

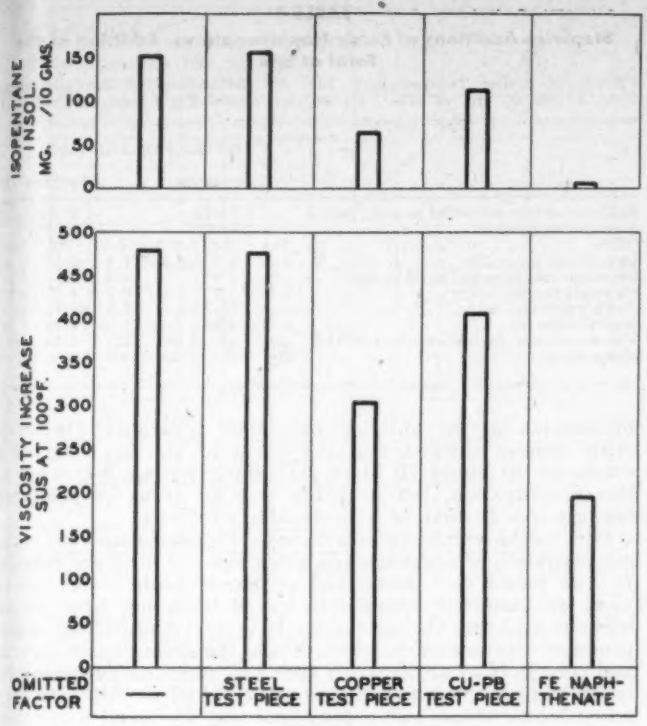

FIGURE 6
Effect of Individual Metallic Components

Oil B-1. Temperature, 280° F. Air rate, 70 liters per hour. Time, 36 hours. Catalyst, 0.02% Fe_2O_3 as naphthenate in benzene solutions. Metals, 100 sq. cm. of steel, 1.0 sq. cm. of Cu, 4.4 sq. cm. of Cu-Pb.

Effect of Blow-By Materials. Other catalysts could enter the oil from the combustion space with the blow-by gases. The end products from the Ethyl fluid are among the most important of these and are usually lead bromide and sulfate. It was reported[2] that these have little or no effect upon the oil; later investigations have shown that lead bromide can have a powerful catalytic effect upon some oils but that lead sulfate does not.[2,10] Ethyl fluid itself has an analogous effect[9]—for example, both ethyl fluid and lead bromide were harmful to a Pennsylvania oil but not to an acid-treated Mid-Continent oil. It is well established that lead halides, particularly the bromide, are present in the blow-by in an engine.[10] Therefore, it was considered essential that lead bromide be included as a catalyst in a laboratory test. The quantity to be used was deduced from the volume of blow-by and average lead content of the gasolines This corresponded well with the lead content of typical oils from several Chevrolet oil test engines and amounted to 0.10 weight percent of the oil. Figure 7 shows the effect of various amounts of lead bromide upon oil B-1 in the laboratory test. This was typical of an oil which was influenced substantially by lead bromide catalysis.

Gaseous blow-by material can also have an effect. The oxides of nitrogen were shown to be pro-oxidants,[5] but in normal non-knocking operation and at moderate compression ratios their concentration in the blow-by gases is not thought to exceed 0.01 percent.[7] This quantity of oxides of nitrogen failed to affect the results in the authors' laboratory procedure. Two of the gaseous components peculiar to rich mixture operation are carbon monoxide and hydrogen, which have been found by the present authors[3] and by Mougey and Moller[14] to act as inhibitors for oil deterioration. Table 2 shows this effect in the laboratory procedure. However, the air-fuel ratio of the standard Chevrolet test is chosen so that these gases are substantially absent. Accordingly, it was not considered necessary to include them as standard factors in laboratory procedure.

TABLE 2
Effect of Blow-by Materials Peculiar to Rich Mixture Operations

Blow-by Material	....	5% CO in air	....	3% H_2 in air
Oil, SAE 20	Inhibited Mid-Continent	Inhibited Mid-Continent	B-2	B-2
Time, hours	20	20	36	36
Temperature, °F	310	310	280	280
Air rate, liter per hour	30	30	70	70
Metals (area per 160 cc. of oil):				
Steel, sq. cm	300	300	100	100
Cu, sq. cm	20	20	4.4	4.4
Cu-Pb, sq. cm	....	....	1.0	1.0
Soluble catalyst, percent Fe_2O_3 as naphthenate (in benzene solution)	....	....	0.03	0.03
Lacquer, mg. per sq. dm	10.5	5.2	0.0	0.2
Cu weight loss, mg. per 10 sq. cm.	6.1	5.2	17.0	13.0
Cu-Pb weight loss, mg. per 10 sq. cm	....	....	56.3	30.5
Neutralization No	....	....	4.50	3.80
Viscosity increase, Saybolt seconds at 100° F	178	119	2317	797
Sludge rating	B+	B+	B+	A
Naphtha-insolubles	4.8 vol. %	4.0 vol. %	0.2 mg. per 10 grams	1.1 mg. per 10 grams

Effect of Temperature. The temperature at which an oil is oxidized in the presence of catalysts is a very important factor in the rate of deterioration. In the engine the bulk of the oil is at the crankcase temperature, but a small amount is exposed to the higher temperature of the ring zone. The Chevrolet test is operated at 280° F. crankcase temperature on the heavy-duty test. Temperatures of 265°, 280°, 300°, 315°, and 330° F. were examined in the laboratory test procedure for correlation with the engine results. Of these, the actual crankcase temperature 280° F. was as suitable as any and was consequently chosen for heavy-duty correlation.

The possibility that the higher ring belt temperatures could have a specific effect on certain oils or inhibitors in the presence of catalysts cannot be neglected. Rather than attempting a compromise temperature for a single test, it is believed that a separate temperature tolerance test should be made at the higher temperature. An average temperature in this zone is 350° F. and the authors have adopted this temperature for estimating the temperature tolerance of any oil that is promising in the primary correlating test. The use of this procedure is discussed below under tolerance tests.

Effect of Duration of Test. A large number of these tests can be made at once and consequently for most work it is not essential that the rate of deterioration be accelerated over that obtained in engine testing. It is possible to decrease the dura-

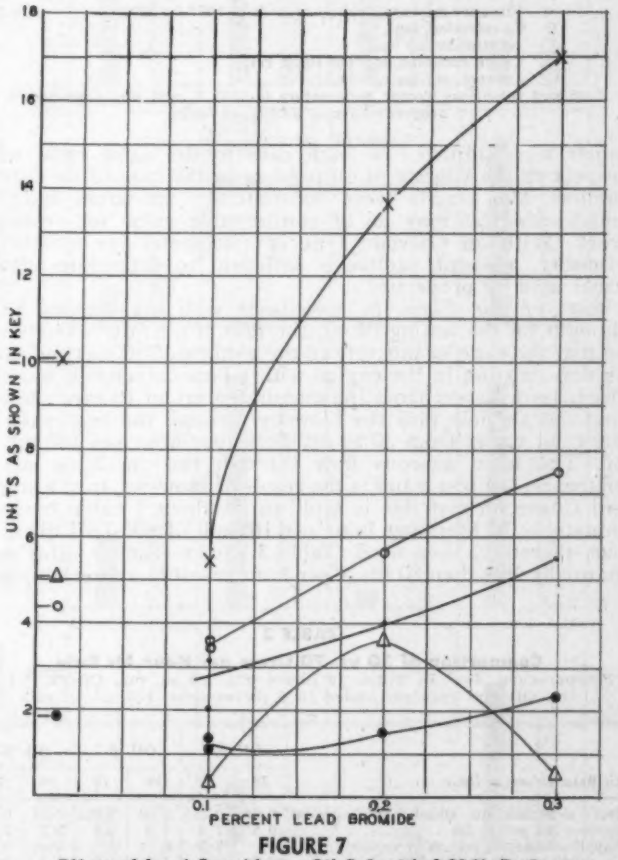

FIGURE 7
Effect of Lead Bromide on Oil B-1 with 0.01% Fe_2O_3

- • Lacquer, mg.
- O Viscosity increase, Saybolt seconds at 100° F.
- ● Neutralization No.
- △ Cu-Pb weight loss, mg. per 10 sq. cm.
- × $CHCl_3$-solubles, mg. per 10 sq. cm.

tion of a test by increasing the temperature, as in the temperature tolerance test. However, this might increase the uncertainties of an already complex field.

Volume of Oil. The usual procedure was to use a 160-ml. sample of oil. However, tests have been made on 35-ml. samples in which the metal areas, air rate, and size of the container were adjusted in each case to the same ratio with respect to the volume of oil used as in the case of the larger sample. The results were substantially the same and the small-scale test may be of considerable value for research work. With an Ostwald type of viscometer for measuring viscosity, a 35-ml. sample is sufficient to determine all the usual used oil properties.

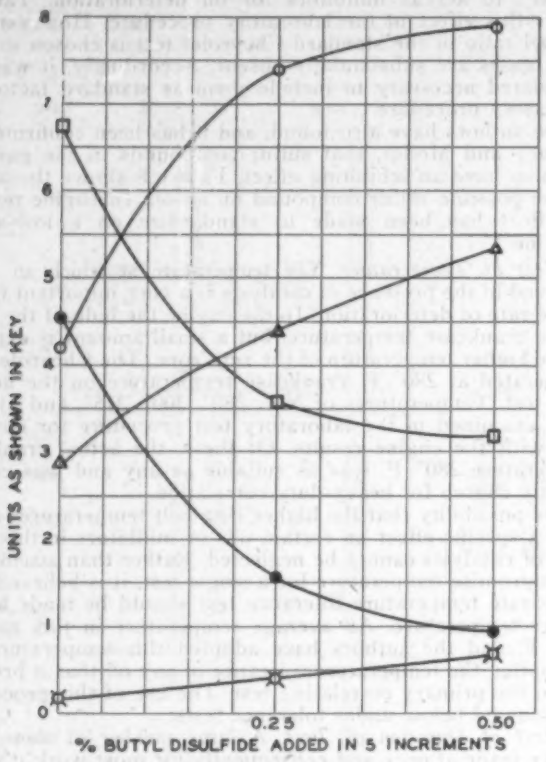

FIGURE 8
Effect of Butyl Disulfide on Oil B-2

● Viscosity increase, Saybolt seconds at 100° F./1000.
○ Cu corrosion, mg.
□ Neutralization No.
△ Cu-Pb corrosion, mg. per 10 sq. cm.
⊕ Lacquer, mg. per sq. dm.
Standard conditions except temperature is 300° F. and iron naphthenate concentration is 0.04% as Fe_2O_3.

Rate of Air Flow. In accordance with the authors' basic thought on the testing of oil, the rate of air flow was chosen so that the ratio of this rate to the volume of oil was the same as that existing in the engine with which correlation was desired. Information from the manufacturers of 10 cars showed that the air flow plus the blow-by through the crankcase on the road varies from 30 to 350 liters per hour per 160 ml. of oil. The main gaseous flow through the crankcase of an engine on the test stand is the result of blow-by. In the standard Chevrolet test this is said[12] to be about 1 cubic foot per minute or 70 liters per hour per 160 ml. of oil. This quantity has, therefore, been used. Table 3 shows that air rates substantially less than 70 liters per hour result in appreciably less breakdown in the authors' particular apparatus. However, other studies showed that the effect of air rate reached a maximum at about 70 liters per hour. Dry air was used in this investigation, but probably wet air is to be preferred because it will disclose hydrolyzable additives.

TABLE 3
Comparison of 30 vs. 70 Liters per Hour Air Rate
(Temperature, 300° F. Time, 36 hours. Cu, 1.0 sq. cm. Cu-Pb, 4.4 sq. cm. Oil and catalyst added in 5 increments, 160 ml. of oil)

	OIL B-1		OIL B-2		OIL B-3	
Air Rate, Liters per Hour	30	70	30	70	30	70
Fe_2O_3 as naphthenate (added as solid), percent	0.04	0.035	0.04	0.035	0.04	0.035
Lacquer, mg. per sq. dm	0.5	2.8	1.2	4.9	0.5	7.3
Naphtha-insolubles, percent by volume	0	2.5	0	0	Trace	0
Cu weight loss, mg. per sq. dm	0.7	0.0	1.5	1.9	0.1	0.2
Cu-Pb weight loss, mg. per 10 sq. cm	2.2	4.3	4.9	18.7	22.3	33.5
Neutralization No.	1.2	1.28	3.4	3.42	2.7	2.19
Viscosity increase, Saybolt seconds at 100° F.	197	266	264	480	122	160
Sludge rating	A+	B+	A+	B+	A	A—

TABLE 4
Stepwise Additions of Ferric Naphthenate vs. Addition of the Total at Start
(Time, 36 hours. Temperature, 300° F. Air rate, 70 liters per hour. Metals, 100 sq. cm. of steel, 4.4 sq. cm. of Cu-Pb, 1.0 sq. cm. of Cu.)

	METHOD OF ADDITION					
	5 Increments			All at Start		
Fe_2O_3 as naphthenate (added as solid), percent		0.035			0.010	
Average concentration		0.022			0.010	
Oil No.	B-1	B-2	B-3	B-1	B-2	B-3
Lacquer, mg. per sq. dm	2.8	4.9	2.3	1.8	3.8	2.2
Isopentane-insolubles, mg. per 10 grams	....	4.0	....	18.0	6.5	2.7
Cu weight loss, mg.	0.0	1.9	0.2	0.3	4.9	0.3
Cu-Pb weight loss, mg.	4.3	18.7	33.5	7.3	37.7	13.1
Neutralization No.	1.28	3.42	2.19	1.08	4.40	1.29
Viscosity increase, Saybolt seconds at 100° F.	266	480	160	235	1452	68
Sludge rating	B+	B+	A—	A+	A—	A+

One factor which can be affected seriously by air rate is the concentration of organic acids, since some of them are volatile. It was found that acetic and propionic acids were carried away substantially completely by 30 liters per hour of air without affecting the oxidation. It is well known that acidic products do come off in oil oxidation. However, lauric, stearic, and cerotic (C_{26}) acids, when added to an oil on an equimolar basis, had roughly an equal and powerful effect. All were very corrosive to copper and copper-lead and the metal soaps thus formed were powerful catalysts. It was thought that the removal of acids by the air would be about the same in a laboratory test as in an engine, if the air rates were proportional to the respective oil volumes. In correlating work with reported Chevrolet results, the neutralization numbers were equal to and in some cases slightly greater than those of the used engine oil, supporting this concept.

Methods of Addition of Oil and Iron Soap. In life testing oil in engines, some oil is consumed and some is removed for testing, fresh oil being used for replacement. Likewise, fresh iron catalyst is probably made available during the entire course of the run instead of all at once near the start. The fresh oil to be added during the run in the Chevrolet test is about equal in volume to the original charge.[4] Table 4 shows the effect of adding the iron naphthenate in increments as compared with adding it all at the start. The former procedure was much less severe and at least 40 to 50 percent more iron naphthenate was required to bring the deterioration up to that of the latter. Otherwise, the results were similar. Wear studies[4] have shown that much of the "wear-produced" iron is formed during the first part of the engine operation, so that this catalytic factor might best be reproduced by bringing all the iron soap in, at, or near, the start of the test. There seems to be no advantage in replacing the oil during the laboratory test with new oil and it detracts from the simplicity of the procedure.

Application to B Oils

Table 5 shows check tests on the four B oils and deviation of each property. The reproducibility was very good for oils in which the deterioration was not excessive. The larger deviations are found in oil B-4, which was so unstable that the useful life was considerably short of the 36 hours of the test. In a large number of other check tests the reproducibility was as good or better than that shown in Table 5.

TABLE 5
Reproducibility of Test as Measured on B Oils
(Time, 36 hours. Temperature, 280° F. Air rate, 70 liters per hour. Metals, 100 sq. cm. of Cu-Pb, 4.4 sq. cm. of Cu. Catalysts, 0.12% Fe_2O_3 as 2-ethyl hexoate, 0.10% $PbBr_2$.)

	OIL B-1		OIL B-2		OIL B-3		OIL B-4	
Lacquer, mg. per sq. dm	3.0	8.0	0.8	0.7	0.1	1.2	43.5	50.1
Isopentane-insolubles, mg. per 10 grams	85.9	119.7	8.8	4.5	8.5	1.0	739.4	873.3
Cu weight loss, mg. per 1.0 sq. cm.	0.6	0.8	2.5	0.7	0.8	—0.3	0.1	0.2
Cu-Pb weight loss, mg. per 4.4 sq. cm.	3.6	4.7	16.7	10.7	0.9	0.1	6.2	8.8
Neutralization No.	2.0	2.3	5.4	4.6	0.5	0.3	5.2	2.8
Viscosity increase, Saybolt seconds at 100° F.	426	317	721	761	37	38	2142	1968
Sludge rating	A	B+	A	A—	A+	A—	E	D—

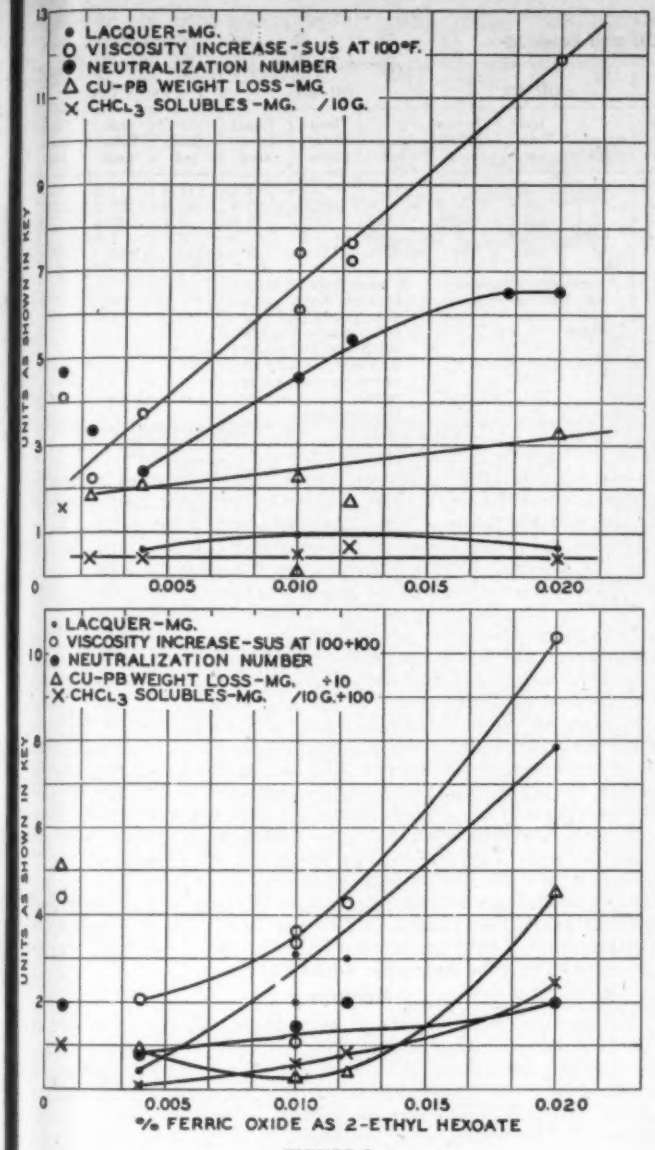

FIGURE 9

Effect of Ferric 2-Ethyl Hexoate

Above. Oil B-2 with 0.1% lead bromide.
Below. Oil B-1 with 0.1% lead bromide.
Time, 36 hours. Temperature, 280° F. Air rate, 70 liters per hour. Metals. 100 sq. cm. of steel, 4.4 sq. cm. of Cu-Pb, 1.0 sq. cm. of Cu. Ferric 2-ethyl hexoate added as solution in C.P. benzene. 0.10% lead bromide with surface area of 1.0 sq. meter per gram. Passed 250 mesh.

The reproducibility of the results depends largely upon the accuracy of the temperature control, which should be ± 1° F. or better, and the addition of the iron soap.

Correlation with Engine Tests. As a basis for engine performance, the authors took the Chevrolet test work sponsored by Subdivision B of the Lubricants Division of the S.A.E. Standards Committee and reported by Mougey and Moller.[13, 14] This work involved the testing of four oils in the Chevrolet engine by 14 laboratories.

All the factors entering the oil test except that of iron soap content were selected to correspond to the respective value of those factors in the engine test. Figure 9 shows that the iron soap concentration was also a very important factor. The selection of a correlating concentration, 0.012 percent (as Fe_2O_3), was based on the results of studies on B oils of which Figures 9 and 10 are typical. The reported results of the 14 participating laboratories have been averaged and compared with the laboratory results in Figure 10. The relative correlation of laboratory and engine sludge rating was also good with one exception, oil B-3, which was rated better than the engine tests. Recent engine data of several laboratories have given it a higher rating than before, as shown in the shaded area of this bar. This was more in accord with the laboratory results.

The isopentane-insoluble material in the used oils from this test were usually completely soluble in chloroform. However, in the used oils from the engine tests a substantial part was insoluble in chloroform. This was probably due to materials entering the oil from the combustion zone and the breather pipe of the engine.

The correlation with all the oils was good on viscosity increase.

The corrosion of the pieces of copper-lead bearings, Figure 9, in the laboratory procedure was usually considerably less than in the engine, probably because of the absence of

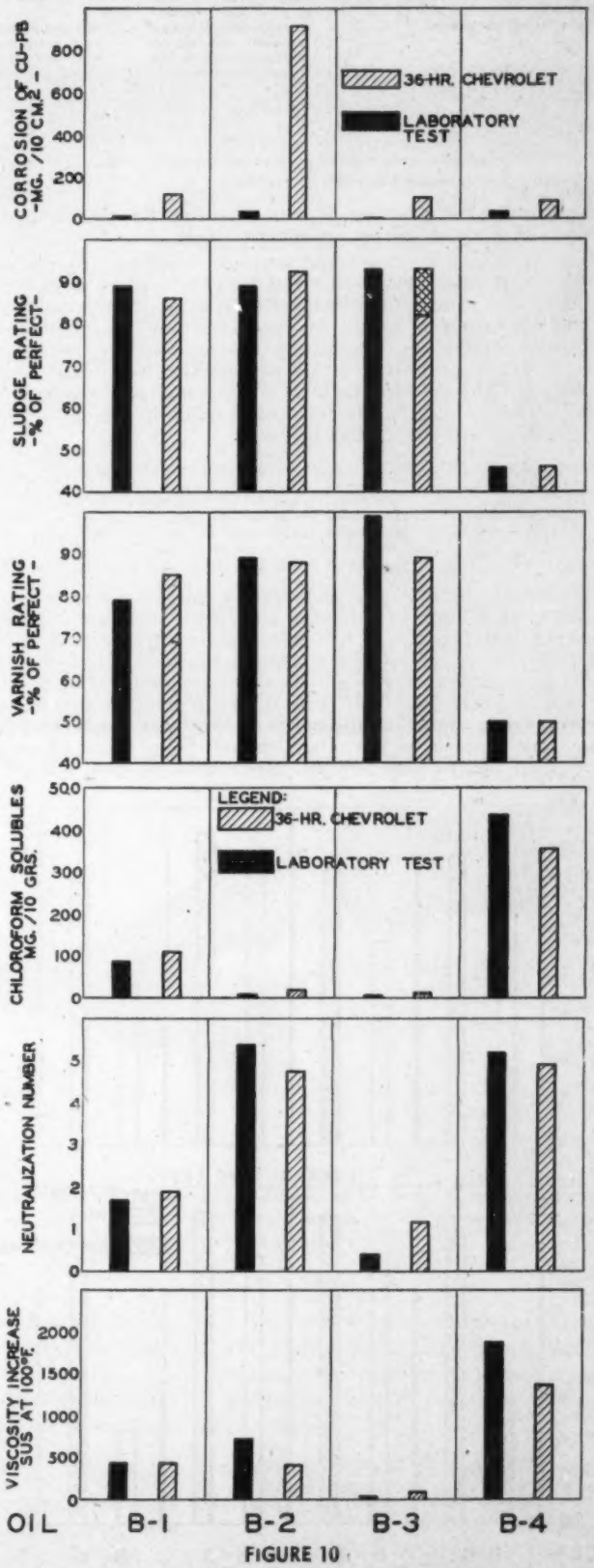

FIGURE 10

Correlation between Average Chevrolet Test and Standard Laboratory Test

TABLE 6
Oxidation Test on X Oil and Penn 30

TYPE OF TEST	OIL AX			OIL BX			OIL CX			OIL DX			PENN OIL 30		
	Standard	Iron Tolerance	Temp. Tolerance	Standard	Iron Tolerance	Temp. Tolerance	Standard	Iron Tolerance	Temp. Tolerance	Standard	Iron Tolerance	Temp. Tolerance	Standard	Iron Tolerance	Temp. Tolerance
Lacquer	0.0	5.0	1.2	7.6	8.6	3.5	19.5*	2.0	1.7	11.3	1.4	2.8	15.6	1.5	10.4
Isopentane-insoluble	355.7	336.0	177.3	222.2	830.6	320.6	1.2	193.7	58.8	0.9	23.3	22.8	201.9	228.0	72.7
Cu-Pb weight loss	1.0	0.8	0.5	6.2	66.5	12.6	0.4	3.7	0.3	2.1	42.7	17.8	3.8	16.4	13.8
Neutralization No.	1.2	4.5	1.5	1.3	7.7	1.4	0.9	4.5	0.9	0.5	3.8	1.0	1.9	1.9	1.0
Viscosity increase	429	227	409	308	542	588	66	184	94	38	179	83	493	1095	430
Appearance	C	C+	B	A	C+	A—	A—	A—	A—	A	A—	A—	B	A	B+
Engine service characteristics	A heavy-duty oil having excellent oxidation resistance properties but limited in detergency			A heavy-duty oil having good detergency properties but limited in oxidation resistance			A heavy-duty oil possessing both detergency and resistance to oxidation			A heavy-duty oil satisfactory both as to detergency and stability under limited conditions but which may oxidize and/or corrode bearings under certain high temperature conditions					

* Probably error, as there was no visible lacquer film.

vigorous mechanical action. It is not felt that the present procedure will evaluate corrosion quantitatively.

Once it has been established that an oil shows promise in the above standard test, which was based to a large extent on the particular composition of the B oils, it becomes important to know whether it would tolerate excessive amounts of a particular catalyst or the higher temperatures in the ring zone. For this purpose a series of tolerance tests has been employed. The operating factors of the primary test save one were retained and separate tests were made in which one of the variables was changed as follows:

Type of Tolerance Test	Change in Concentration or Condition
Iron	Increased from 0.012 to 0.05%
Lead bromide	Increased from 0.1 to 0.4%
Temperature	Increased from 280° to 350° F. and time reduced from 36 to 10 hours
Copper	Increased from 1 to 4 sq. cm.

In general, the iron and temperature tolerance tests are of greatest importance, as is illustrated below. The results of the tolerance tests on the B oils which were correlated by the standard test procedure are shown in Figure 11. Except for oil B-3, the temperature tolerance data were better or equal to the standard test data. This indicates a low-temperature sensitivity of these oils. In contrast, excess iron was deleterious in some way to each of the oils, although some were affected more than others. The engine appearance on B-4 was improved somewhat, possibly owing to some detergent action of the iron soap. Everything considered, B-3 remained the best oil and B-4 the poorest. On the other hand, studies have been made on a certain type of inhibitor-oil combination, which was not affected by the standard or the iron tolerance tests but was seriously harmed by the temperature tolerance conditions. This was reflected in poorer results from the Chevrolet tests than from the "standard" laboratory test. The prediction based upon the temperature tolerance test was that increased concentrations of inhibitor would be necessary for a successful Chevrolet test. This proved to be the case.

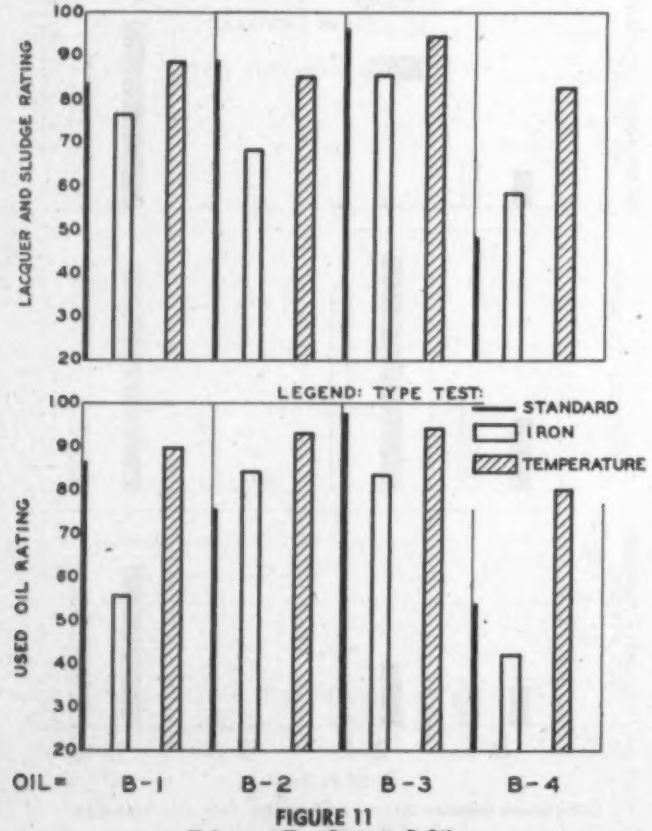

FIGURE 11
Tolerance Test Data on B Oils

Results on Some Other Known Oils. The utility of any laboratory test rests in its application to the evaluation of an oil of unknown performance. The above work has shown the test to be applicable for determining oil stability for B oils which represent a fairly divergent group. However, there are many types of oils and additives which may or may not respond as well. Table 6 shows a group of oils known as the X oils for which the service characteristics have been determined but not yet released by the Corrosion Section of the Technical Committee B, Committee D-2 of the A.S.T.M. A Penn oil is also included. These are shown with the objective that service correlation may be available sometime.

Summary

The service requirements of lubricating oils are so varied as to make their refining and testing extremely difficult. Indeed, the "service performance" of an oil is a very vague term. In the present work by the application of reasonable chemistry a laboratory test procedure has been developed which gives substantial correlation, except for corrosion, with one type of "service" and for a certain few oils; but this development is by no means complete. By the application of certain "tolerance" tests a fundamental understanding of the mechanisms of various additives and of the decomposition of an oil is possible to a greater extent than with engine tests. Application of the principles developed may be of substantial aid to both routine testing and research work in the field of motor oils. However, completely satisfactory procedures must also give information upon bearing corrosion. A procedure for doing this in the proposed test is under investigation and will be reported later.

ACKNOWLEDGEMENT

The authors are indebted to M. H. Campbell, C. W. Hiatt III, H. P. Lankelma, J. M. Musselman, R. I. Potter, and M. L. Sunday for suggestions and much of the laboratory and engine work described herein.

LITERATURE CITED

[1] Am. Soc. Testing Materials, Committee D-2, Proc. Am. Soc. Testing Materials, 42 (1942), appendix.
[2] Anon., *Oil Gas J.*, **38**, No. 30, 54 (1939).
[3] Burk, R. E., Hughes, E. C., Scovill, W. E., and Bartleson, J. D., paper presented at the 102nd meeting of American Chemical Society, September, 1941.
[4] Davis, L. L., *Refiner*, **21**, No. 4, 107 (1942).
[5] Davis, L. L., Lincoln, B. H., Byrkit, G. D., and Jones, W. A., *Ind. Eng. Chem.*, **33**, 339 (1941).
[6] Dornte, R. W., and Ferguson, C. V., *Ibid.*, **28**, 863 (1936).
[7] Egerton, A. C., "Science of Petroleum," Vol. IV, p. 2921, London, Oxford University Press, 1938.
[8] Hanson, T. K., and Egerton, A. C., *Proc. Roy. Soc., London*, **163A**, 90 (1937).
[9] Lamb, G. G., Loane, C. M., and Gaynor, J. W., *Ind. Eng. Chem., Anal. Ed.*, **13**, 317 (1941).
[10] Larsen, R. G., and Armfield, F. A., *Ind. Eng. Chem.*, **35**, 581-8 (1943).
[11] Matthijsen, H. L., *J. Inst. Petroleum*, **26**, 72 (1940).
[12] Mougey, H. C., *Am. Soc. Testing Materials Bull.* P. 34 (October, 1939).
[13] Mougey, H. C., and Moller, J. A., Am. Pet. Inst., meeting at San Francisco (Nov. 3, 1941).
[14] Mougey, H. C., and Moller, J. A., S.A.E. meeting at Detroit (Jan. 16, 1942).
[15] Pigott, R. J. S., S.A.E. Detroit meeting (Jan. 6, 1942).
[16] Rugg, H. M., Pennsylvania Grade Crude Oil Assoc. (private communication).

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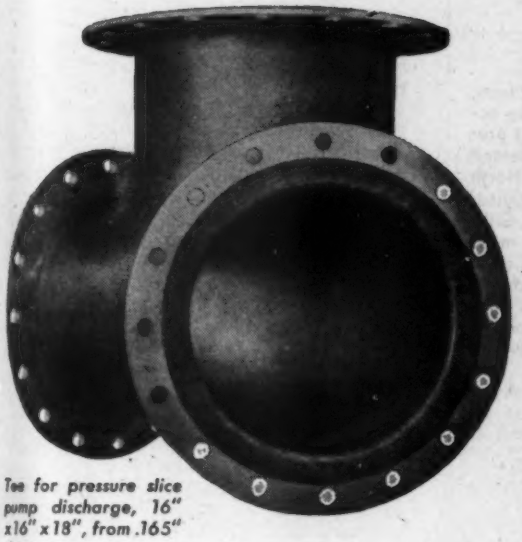

Tee for pressure slice pump discharge, 16" x16" x 18", from .165" sheet copper

Tapering evaporator connection, 42" to 36" diameter, from .250" sheet copper

Steam belt for evaporator, 9' 1.25" diameter x 42", from one sheet of 5-16" copper. Contains Muntz Metal head ½" thick, and 800 copper tubes. Finished weight, 17,000 lbs.

Special elbow, 18" x 14" x 18", made from .165" sheet copper

Flanged elbow for paper stock, 24" diameter, from .165" sheet copper

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Synthetic Rubber Production More Than Million Long Tons

E. R. GILLILAND

IN A PERIOD of about 2½ years and at a cost of $750,000,000 a synthetic-rubber industry was built which is capable of producing over 1,100,000 long tons of rubber polymer per year. This is 60 percent more than was ever consumed by the pre-war rubber industry.

What are the chance that these plants will survive as a permanent industry? The answer to this question involves a number of factors such as: How does the synthetic rubber compare in quality and cost with natural rubber? How desirable is it to our economy from a security standpoint to have a rubber industry within our borders? How desirable is it to maintain a new industry that will be a source of employment and national income instead of supporting other sections of the world that could supply our rubber needs?

Before considering these questions it will be desirable to review briefly what the present industry involves and how it was possible to build this successful chemical industry in such a short time.

Prior to 1942 synthetic rubber was produced in the United States on a small scale (20,000 tons a year), essentially all of which was for special rubber uses in which the synthetics were superior to natural rubber. These operations were carried out as private enterprises by a few of the chemical, rubber, and petroleum companies. With the setbacks of the Pacific war it became necessary to expand synthetic-rubber production and particularly to produce general-purpose polymers on a large scale in order to meet the demands of the Armed Services, transportation industry, and other essential civilian products.

Many of you will recall the very active days in the early part of 1942 when the synthetic-rubber program was expanded almost weekly. This finally culminated in the appointment of the Baruch Committee which was to survey the field and make recommendations. This committee recommended that the program be expanded still further to build an industry with a capacity of 1,100,000 long tons of synthetic rubber per year.

This program was composed of four types of polymers: Buna S amounting to 76 percent of the total, Butyl to 12 percent, neoprene to 6 percent, and Thiokol N to 6 percent. The Thiokol N was later dropped and the present program consists of the other three polymers about in the ratios given. The rated capacity of the present plants is 840,000 instead of the 1,100,000 long tons per year recommended by the rubber survey committee. This cutback was made as experience was obtained on the actual capacity of the plants. Even with the reduced rated capacity the industry can produce more synthetic rubber than was recommended by the Baruch Committee.

THE accompanying text is the address, delivered by Dr. Gilliland upon the occasion of his acceptance of the first presentation of the Leo Hendrick Baekeland Award, which he received from the North Jersey Section of the American Chemical Society. The award was made to Gilliland in "recognition of his unusual merit at 36 as a professor of chemical engineering at Massachusetts Institute of Technology, his creative work in synthetic chemistry, and his outstanding accomplishments as assistant rubber director."

The award is to be given biennially to an American chemist who has not yet reached his fortieth year. It consists of a gold medal and $1,000.

For a long period a general impression existed among a large number of well-informed people that the quantities of rubber recommended by the Baruch Committee were completely out of reason and would never be utilized. The excellent judgment of the committee is now being demonstrated. In 1945 the synthetic-rubber industry will produce between 900,000 and 1,000,000 long tons of synthetic rubber. For 1946 the projected production is 1,100,000 long tons. When one considers the continued scarcity of rubber products for the civilian economy there is certainly no indication that we have an excessively large synthetic-rubber industry.

These projects are referred to as the government synthetic-rubber program, and this certainly gives an incorrect impression of the extent to which the government was responsible for it.

In the early part of 1942 meetings were held and the various industries were asked for their suggestions relative to synthetic-rubber production. A number of the chemical, petroleum, and rubber manufacturing companies submitted proposals. As a result of these meetings several groups were formed and agreements were made in the various fields for exchange of information between the different companies, for financial and legal arrangements necessary for government use of this information, and for continued research and development work. A program was established and construction of the plants initiated. In this construction program various members of the different industries were selected to supervise the actual constructional details and to handle the operation of the finished plants for Rubber Reserve Company.

Altogether, approximately 40 large plants were started, but there was considerable disagreement as to the correctness of the Rubber Reserve Company decisions, with special groups honestly convinced that serious errors in judgment had been made. There was likewise a serious shortage of materials during this period and many people questioned the real necessity of a synthetic-rubber industry of the size then programmed.

The Baruch Committee studied these questions and came to the conclusion that although an improved program could be made, the rubber situation was becoming so serious that the logical procedure was to "bull" the program through with the fewest changes possible and as synthetic rubber was so important to the military and civilian economy that it should be given the highest priority help possible. The Office of Rubber Director was established to carry out these recommendations. This office was fortunate in having William Jeffers and Bradley Dewey as bosses, and when the construction period was completed and the plants were in successful operation, the Office of Rubber Director was terminated.

How was it possible to build this successful industry in such a short time? It is interesting to consider what types of companies were able to make major contributions to this achievement. The number is not large, and the major contributions came from a relatively few of the larger companies of the petroleum, chemical, and rubber-manufacturing industries. These same companies, together with a few of the large engineering companies, carried out the design of these plants. Modifications and improvements have been made since the program was initiated, but as it stands today the plants are built largely on the knowledge these few companies had in 1942. The government supplied only the financial, administrative, and priority assistance to industry. Thus, the success of the synthetic-rubber program is a real demonstration of the ability of private industry.

We are often told of the advantages to the nation of large numbers of small industries rather than the large corporations, but it would have been impossible to solve the rubber emergency without the forward-looking research of these large companies that had been carried on in prior years without any governmental encouragement. The educational institutions, which are usually considered a source of research and technical information, did not supply any great portion

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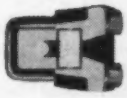

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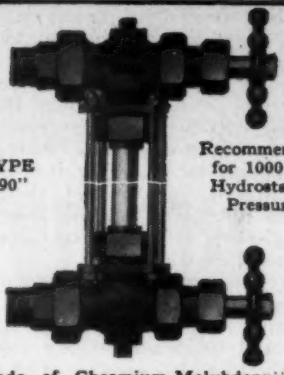

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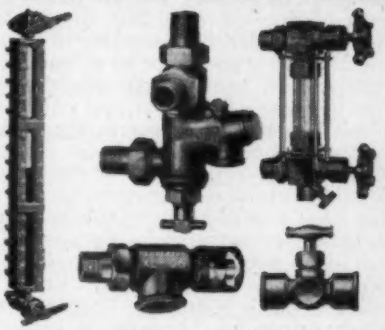

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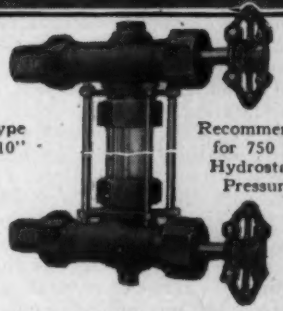

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of the direct technical and development data necessary for this program. Their major contribution was in supplying the industry with highly trained technical personnel for research and development.

For our future security it will be desirable to determine what made it possible for these companies to have the necessary research and development data available, and to have the assurance that such conditions will continue to prevail.

To return to the questions of the future: How does synthetic rubber compare in quality and cost with natural rubber? The simplest of these questions to answer is the one related to quality.

The wide use of rubber was not due to any one property, but was a result of the fact that it possessed a number of characteristics which could be exploited for different uses—for example, it combined high strength with high elongation; it was elastic over wide ranges of temperature; it was extremely resistant to abrasion; its permeability to air, water, and certain other materials was low; its resistance to cutting was high; it could stand repeated flexing; and it could be easily processed and fabricated.

In almost any one of these characteristics there is a synthetic rubber that is at least equal or superior to natural rubber. Neoprene and butyl rubber combine high tensile strength with high elongation. Buna N and neoprene are much more resistant to chemical attack than natural rubber. All of the polymers show relatively low permeability, and butyl is particularly outstanding in this characteristic. Certain of the synthetics are superior for low temperatures; others are superior for high temperatures; and still others are superior in flex resistance.

These superior qualities have led to many improved rubber products, and they will result in many more. However, none of the present synthetic polymers is superior to natural rubber in all respects. In automobile tires a combination of properties is required, and natural rubber possesses this desirable combination to a higher degree than any of the present synthetics. In fact, buna S which was not indicated as being superior in any single respect to natural rubber is the main polymer used to replace it in tire construction. Buna S is a good all-around general purpose rubber, but it is not outstanding in any particular characteristic. The deficiencies of this polymer relative to natural rubber are not serious for the quality of small tires. The chief drawback of this particular synthtic rubber is the fact that at high temperatures its desirable physical properties decrease much more rapidly than do the corresponding properties of natural rubber. In small tires the temperatures encountered are not high enough to make this loss in physical property serious, but in large high-speed tires the condition becomes such that the present buna S type rubber is not satisfactory. Great improvements are being made, and at the present time polymers of the buna S type have been developed in the laboratory which have good high-temperature properties. They offer the promise of being greatly superior to the present synthetics and may be equal or superior to natural rubber for tire purposes.

At the present time the synthetic polymers available can replace natural rubber for about 75 percent of the tonnage to give products of satisfactory or superior quality. Another 15 percent can be replaced to give products of usable but inferior quality. The remaining 10 percent require natural rubber. Real improvements are being made and I feel confident that within five years synthetic rubber will be the equal of natural rubber for all uses.

Sufficient experience has been obtained to make a preliminary cost comparison. Rubbers such as neoprene and buna N were being used prewar due to the fact that their special properties made them superior to natural rubber in certain products and even though their production costs are higher than probable future prices for natural rubber, their postwar use will be greatly increased due to the lowering of costs as a result of large-scale operation. However, it does not appear that either one of them in its present form will become a large-scale general-purpose rubber such as is used for tire production.

Butyl rubber will also be used for certain special purpose products. Recent operating results indicate that butyl rubber could be produced and sold profitably for 15 to 18 cents a pound. At these prices it should be extensively used in the production of inner tubes because of its superior quality. It has not been adequately evaluated for tire construction but it should offer real possibilities along these lines.

The use of these special synthetics should correspond to a consumption of at least 100,000 long tons a year.

Buna S is the main general purpose rubber of the emergency program and will be the chief competitor of natural rubber. It does not seem probably that this competition will become serious for several years. Even after the rubber-producing areas are recaptured there will be a period of almost a year before they can be brought back into reasonable operation. In addition, for several years the world probably will consume large quantities of synthetics and natural rubber to meet the deferred demands. Therefore, it seems most likely that the real competition will develop in the early 1950's. At the present time the quality of buna S is not equal to natural rubber for a number of large-tonnage uses. This difference in quality will be reduced or reversed by improvements in the synthetic, and it seems reasonable to assume that by 1950 it should be of at least equal quality. The competition should therefore be largely based on cost considerations. The largest factor in the cost of producing buna S is the cost of butadiene. From petroleum butylenes it is possible to produce butadiene for an out-of-pocket cost of about 8 cents per pound with the present price of butylene. This cost does not include any provision for amortization, sales expense, profit, or interest on investment. Postwar, with lower prices for butylene, it might be possible to make butadiene for 6.5 cents a pound.

The butadiene-from-alcohol process has been extremely successful, and it has been the major producer so far during the emergency. The plants are of simple construction, and the operating costs are very low. However, at the present time the alcohol cost to the plants is over 90 cents per gallon, making the butadiene out-of-pocket cost over 40 cents a pound. Even with alcohol at 15 cents a gallon the out-of-pocket cost of butadiene is several cents a pound more than from butylene. It has been hoped by many that the synthetic-rubber industry might be an outlet for agricultural products, giving us "home-grown" rubber. It will be impossible to produce alcohol for even 15 cents a gallon from corn or wheat unless the farmers are willing to accept a low price per bushel for the grain. The prices of grain which were supported by the government before the war would make butadiene cost about 15 cents a pound. Such a price for butadiene would make it difficult for synthetic rubber to compete with natural rubber on a cost basis, and unless subsidies are included it is not likely after the present emergency is over that butadiene will be produced from alcohol.

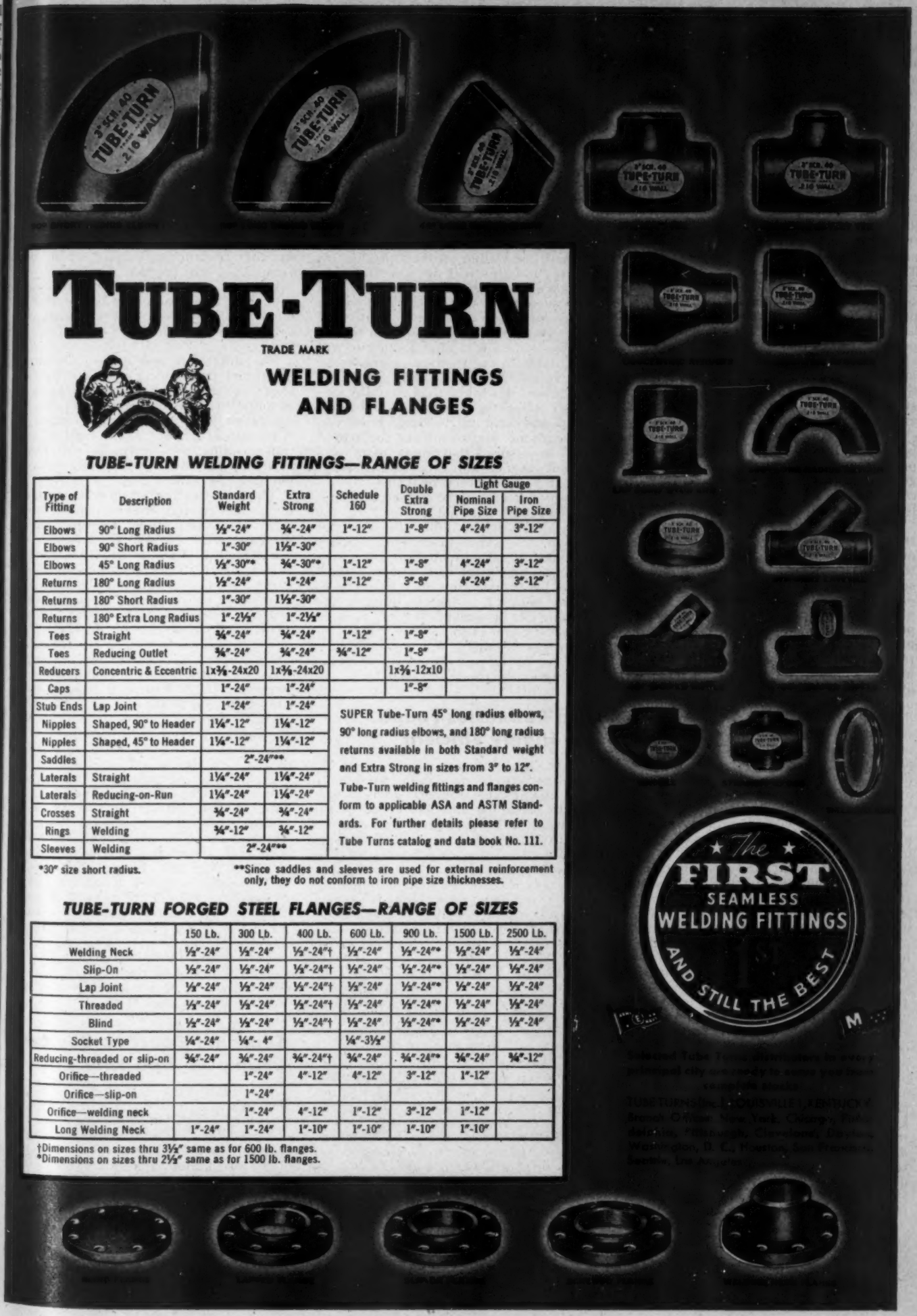
With butadiene from 6.5 to 8 cents a pound, as could be produced in the petroleum plants, the out-of-pocket cost of buna S should not be over 11 cents a pound and it should be possible to sell it at 15 cents a pound and receive an adequate profit and return on investment. The capacity of these low-cost butadiene plants should be sufficient to allow the production of 400,000 to 500,000 long tons of buna S per year.

On the basis of cost of production and quality of product, the present plants could therefore form a new industry producing from 400,000 to 600,000 long tons of synthetic rubber per year and serve as the nucleus for a permanent operation. To realize this possibility it will be necessary to place the units on a self-sustaining basis.

The transition from the present government setup to one that is self-sustaining will be difficult. I do not have any doubts relative to the ability of the chemists and engineers to develop synthetic rubbers until they are better in quality and cheaper than natural rubber, but I do have doubts relative to the job of transferring from the present government setup to a self-sustaining basis under private ownership. This transfer is necessary if a virile and progressive synthetic-rubber industry is to be maintained. Essentially the whole synthetic-rubber program was carried out on the basis of complete government ownership. The plants were built in a large number of localities usually adjacent to a supply of raw materials and the supervising group for construction and operation was in general the petroleum, chemical, or rubber company whose private plant was in the same vicinity. The government agencies themselves do not have the technical knowledge or sufficient technical personnel to operate these plants directly. They could organize such staffs and make it a complete government operation.

To make this successful the government would have to establish large research and development groups in order to improve the operations and the polymers. Otherwise with the great progress that is being made, the plants would soon be obsolete. It would also involve all the usual problems of government operation.

Another possibility is to continue operation as at present. This brings up several problems: first, as to whether the companies would be willing to continue in their capacity as supervisors and operators after the emergency is passed, and second, how should taxes, amortization, and other charges be handled to make this a self-sustaining industry rather than a subsidized one. A third method has recently been proposed by the Attorney General who suggested that the war plants be leased to industry for a period of five years, at the end of



TUBE-TURN WELDING FITTINGS—RANGE OF SIZES

Type of Fitting	Description	Standard Weight	Extra Strong	Schedule 160	Double Extra Strong	Light Gauge	
						Nominal Pipe Size	Iron Pipe Size
Elbows	90° Long Radius	½"-24"	¾"-24"	1"-12"	1"-8"	4"-24"	3"-12"
Elbows	90° Short Radius	1"-30"	1½"-30"				
Elbows	45° Long Radius	½"-30"*	¾"-30"*	1"-12"	1"-8"	4"-24"	3"-12"
Returns	180° Long Radius	½"-24"	1"-24"	1"-12"	3"-8"	4"-24"	3"-12"
Returns	180° Short Radius	1"-30"	1½"-30"				
Returns	180° Extra Long Radius	1"-2½"	1"-2½"				
Tees	Straight	¾"-24"	¾"-24"	1"-12"	1"-8"		
Tees	Reducing Outlet	¾"-24"	¾"-24"	¾"-12"	1"-8"		
Reducers	Concentric & Eccentric	1x⅜-24x20	1x⅜-24x20		1x⅜-12x10		
Caps		1"-24"	1"-24"		1"-8"		
Stub Ends	Lap Joint	1"-24"	1"-24"				
Nipples	Shaped, 90° to Header	1¼"-12"	1¼"-12"				
Nipples	Shaped, 45° to Header	1¼"-12"	1¼"-12"				
Saddles		2"-24"**					
Laterals	Straight	1¼"-24"	1¼"-24"				
Laterals	Reducing-on-Run	1¼"-24"	1¼"-24"				
Crosses	Straight	⅜"-24"	⅜"-24"				
Rings	Welding	⅜"-12"	⅜"-12"				
Sleeves	Welding	2"-24"**					

SUPER Tube-Turn 45° long radius elbows, 90° long radius elbows, and 180° long radius returns available in both Standard weight and Extra Strong in sizes from 3" to 12". Tube-Turn welding fittings and flanges conform to applicable ASA and ASTM Standards. For further details please refer to Tube Turns catalog and data book No. 111.

*30" size short radius.

**Since saddles and sleeves are used for external reinforcement only, they do not conform to iron pipe size thicknesses.

TUBE-TURN FORGED STEEL FLANGES—RANGE OF SIZES

	150 Lb.	300 Lb.	400 Lb.	600 Lb.	900 Lb.	1500 Lb.	2500 Lb.
Welding Neck	½"-24"	½"-24"	½"-24"†	½"-24"	½"-24"*	½"-24"	½"-24"
Slip-On	½"-24"	½"-24"	½"-24"†	½"-24"	½"-24"*	½"-24"	½"-24"
Lap Joint	½"-24"	½"-24"	½"-24"†	½"-24"	½"-24"*	½"-24"	½"-24"
Threaded	½"-24"	½"-24"	½"-24"†	½"-24"	½"-24"*	½"-24"	½"-24"
Blind	½"-24"	½"-24"	½"-24"†	½"-24"	½"-24"*	½"-24"	½"-24"
Socket Type	¼"-24"	¼"- 4"		¼"-3½"			
Reducing-threaded or slip-on	⅜"-24"	¾"-24"	¾"-24"†	¾"-24"	¾"-24"*	¾"-24"	¾"-12"
Orifice—threaded		1"-24"	4"-12"	4"-12"	3"-12"	1"-12"	
Orifice—slip-on		1"-24"					
Orifice—welding neck		1"-24"	4"-12"	1"-12"	3"-12"	1"-12"	
Long Welding Neck	1"-24"	1"-24"	1"-10"	1"-10"	1"-10"	1"-10"	

†Dimensions on sizes thru 3½" same as for 600 lb. flanges.
*Dimensions on sizes thru 2½" same as for 1500 lb. flanges.

which the true value of the plants would be determined. I doubt whether this would be very satisfactory in the case of synthetic rubber. The companies to which the plants were leased would hesitate to make any improvements involving capital expenditures until they were reasonably assured on the final disposal. One thing is certain, five years after the war is over, most of these plants in their present form will be obsolete.

A fourth possibility would be outright sale to private industry.

From the viewpoint of maintaining a live synthetic-rubber industry the first three plans involving continued government ownership do not appear desirable. They would not furnish the necessary incentive for improvements in quality and cost that would be obtained from a competitive industry. These plans would leave synthetic rubber completely dependent on fluctuating government policies. It is improbable that government interest will be such that it will continue to develop and build new and improved synthetic-rubber plants after the present emergency is passed.

Any one of these three plans would practically ensure the slow death of the present units, and at the same time the government operator would retard the construction of new and improved plants by private industry.

The last method, sale to private industry, would be more desirable but it also offers major problems, particularly as to the basis on which the plants should be sold. There are several points of view, one maintaining that synthetic rubber plants, like a battleship or gun, are purely a war necessity and the government should make no attempt to recover the full investment value. The other maintains that these plants are a going industry with possibilities of profitable operation after the war and should be disposed of as such. Most of the plants were in full operation by the early part of 1944. It appears unlikely that they will pass out of government operation in less than two or three years. Thus, on the average they will have operated three to four years and if they were amortized on the same basis as other war emergency plants their remaining cost would not be too great.

It is essential that the taxpayers receive any true value, but too high prices will retard or prevent the development of the industry. The companies will not be interested in purchasing the plants at prices which are a high percentage of the investment. The original costs of construction were high due to the emergency conditions under which they were built, and important developments have been made so that today cheaper and more efficient plants could be constructed. Industry will hesitate to build such new plants if they are unable to purchase the present ones because of the uncertainties as to the manner in which the government will handle its units. Another problem in government disposal is the fact that some of the units are much more desirable than others. If the decision to sell them to private industry is made, do plants that are sold have to carry the load of the ones that are less desirable for postwar operation?

If a few of the units are sold to industry, will the other plants be retained by the government, with the possibility of competitive operation on a basis which private capital would consider unfair?

How desirable is it to our economy from a security standpoint to have a rubber industry within our borders? Our economy requires rubber, and great chances were involved in meeting the present rubber emergency requiring a period of intense research, development, construction, and testing. Numerous processes had to be placed in operation without proper development and failure of any one of a number could have jeopardized the whole program. A number of difficulties and even failures were encountered, but fortunately they were not at key points. The continued use of synthetics will result in improved products and will develop the necessary technical knowledge on their production and use, and this will obviate the gambles taken in the present emergency.

In transferring these plants provision should be made to ensure that they either stay in active operation or in standby operation so that a nucleus will be available to meet future emergencies.

Active operation, of course, would be much more desirable than standby operations since the plants would be improved and kept up to date. However, even with no improvements the nation would be assured that an industry was available that could give rubber polymers of a satisfactory quality.

This industry can be a source of employment and national income. In the years ahead when jobs are a major problem, the synthetic-rubber industry can make a real contribution.

The country's interest would be best served by transferring this industry to private operation as soon as possible and in doing so a great deal of thought should be given as to the best course for protecting the public and still making it attractive for private initiative to develop and improve synthetic rubber.

Nazi Refineries Found Not Highly Efficient

PAW disclosed that a group of technologists has been making studies in Germany of Nazi refinery and oil production methods, and has come to the conclusion that they are less efficient than those in common use in this country, and the quality of products used by the German armed forces, especially gasoline, was inferior to that supplied the military services of the United Nations, largely because of inability to construct and maintain production capacity.

The party consists of technologists from American oil companies and the government. It was assembled in England and followed on the heels of advance elements of the United States armies in order to reach the German oil centers before records could be removed or destroyed and personnel dispersed.

As they followed the troops across France, the investigators learned little of value, since the Germans had not materially remodeled French plants and the Nazi staffs and their records had retreated with their army. In Germany, however, despite the badly damaged condition of plants which had been bombed out of production several weeks before American forces reached them, information of considerable value was obtained.

Tons of records have been recovered and microfilmed for removal to this country for translation and study. In at least one instance it was necessary to discover the hiding place in which information had been secreted.

In most cases, German technicians cooperated with the group, and voluntarily supplied information.

The group reported that several underground refineries had been substantially completed and were about ready to start operation when the war ended. Their construction and location had been discovered in captured enemy documents many months before, but various uncertainties made it difficult for the Allies to determine the productive capacity of the plants which, built in caves, abandoned mines and other natural and man-made shelters, were difficult targets from the air and had to be immobilized by destroying the railroads upon which they were dependent for raw materials.

Inferior quality of German oil products, it was explained, was not due so much to lack of scientific knowledge as to constant hammering of Allied air forces.

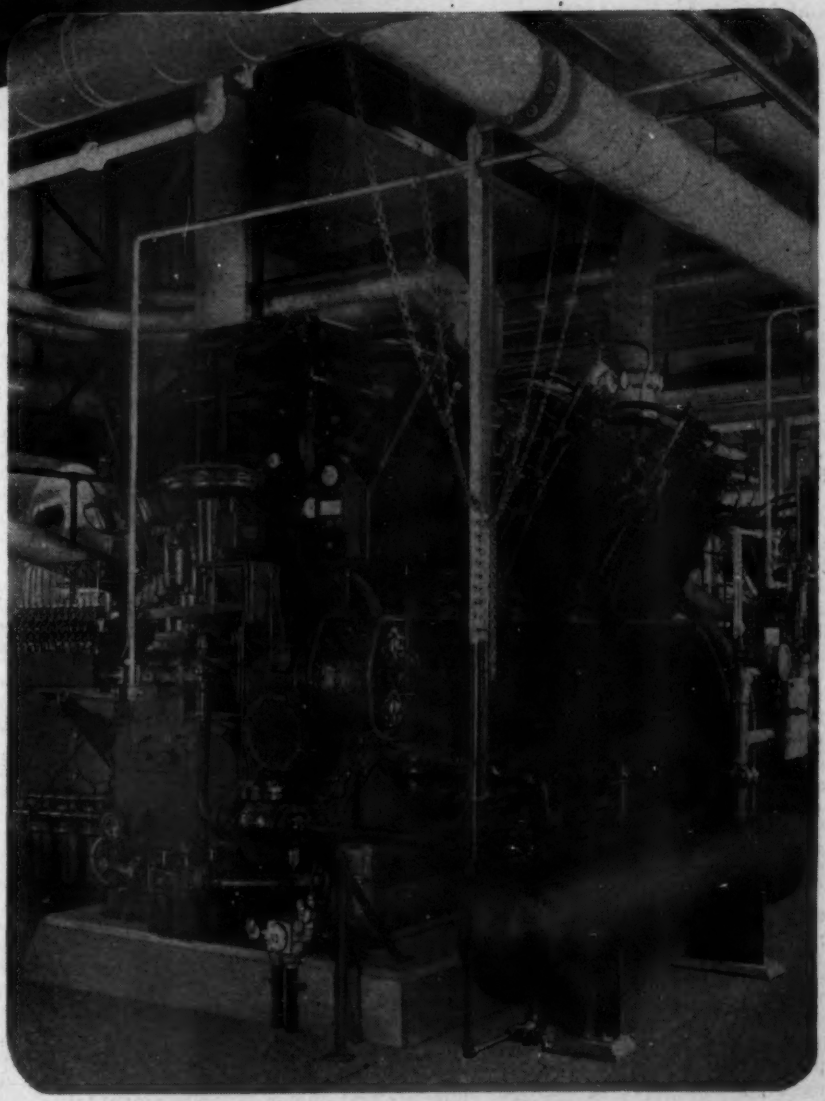
The difference was not so noticeable in ground transport, for which the Germans in their trucks and tanks used gasoline of a lower rating than the 80-octane supplied ground transport in the American army, but in the field of aviation gasoline, the Luftwaffe was forced to fly on gasoline of generally between 90- and 95-octane.

The investigating group was organized under the general direction of C. Stribling Snodgrass, PAW foreign refining director, with Dr. W. C. Schroeder of the Bureau of Mines as field leader, and included: John G. Allen, Phillips Petroleum Company; Harold V. Atwell, The Texas Company; E. L. Baldeschweiler, Standard Oil Development Company; George S. Bays, Stanolind Oil & Gas Company; Leonard E. Carlsmith, Standard Oil Company of New Jersey, Louisiana Division; Ernest Cotton, Gulf Oil Corporation; L. P. Evans, Socony-Vacuum Oil Company; Warren F. Faragher, Houdry Process Corporation; Vladimar Haensel, Universal Oil Products Company; Lester L. Hirst, Bureau of Mines; William A. Horne, Gulf Research and Development Company; Irvin Harvy Jones, Koppers Company; Jean P. Jones, Phillips Petroleum Company; Paul K. Kuhne, Gulf Oil Corporation; Byron L. MacKusick, The Pure Oil Company; Louis L. Newman, Bureau of Mines; William W. Odell, Bureau of Mines; A. R. Powell, Koppers Company; Hans Schindler, The Pure Oil Company; Guenther Von Elbe, Bureau of Mines; Ernest F. Voss, Humble Oil & Refining Company; Horace M. Weir, consulting engineer, and D. S. Fraser, chief of the technical section of the PAW foreign refining division, on temporary assignment as London representative.

Supreme Court to Review Champlin Pipe Line Case

The United States Supreme Court will review a recent decision by a lower court in which it was held that a pipe line constructed by Champlin Refining Company was a common carrier and subject to ICC jurisdiction. The line extends from Champlin's refinery at Enid, Oklahoma, to terminals in Hutchinson, Kansas, Superior, Nebraska and Rock Rapids, Iowa, and is used to transport refined petroleum products. A special three-judge federal court in the Western Oklahoma district held the line was a common carrier within the meaning of the Interstate Commerce Act.

to Miracle Derivatives



During the past thirty years Cooper-Bessemer has furnished many of the Pure Oil Company's engines and compressors. This compressor station in their Toledo refinery illustrates the latest in a "jump by jump" record of progress in engine and compressor development — and it's still going on.

Latest Cooper-Bessemer installation at the Pure Oil Company's Refinery consists of seven modern Type G-MV's totaling 3200 compressor horsepower, compressing air and gas for the production of toluene. Five of the seven G-MV's are shown in the top photograph above.

Automatic speed control as developed by Cooper-Bessemer maintains a discharge pressure that is remarkably constant. In the view at right showing the operating end of one of the above G-MV's, the control mechanism is clearly shown. Flow rate, torque, time cycle, or other desired functions may also be automatically controlled.

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THE MONTH IN THE INDUSTRY

PERENNIAL as the circus, investigation of the oil industry got under way again June 18 by a Senate Oil Investigating committee. Using the same elephants on the same tubs, the performance was broadened to contemplate control of oil affairs throughout the world. Ringmaster for the current show is Senator Joseph C. O'Mahoney of Wyoming, who has been mentioned as possible successor to Secretary of the Interior Ickes, if and when. Indications are that this attempt to shape a national oil policy will put a record number of words into the record. These words, as in former years, include statements of impending depletion of the oil supply, countered by as authoritative reports of sufficiency; recounting of the inexhaustible supplies of liquid fuels from shale and coal; demands that imports be increased to conserve domestic supplies, countered by demands for protection from imports; and on through the repertoire. (More below.)

The Anglo-American petroleum agreement has been revamped to provide for participation of other countries without formalities originally contemplated and which would have required conferences with them. As it now reads there is no inference of price fixing or other "cartel" arrangements, and the international committee set up will have no authority other than consultative. The draft, made by a President's committee after conferences with industry representatives, next is due for discussion between the State Department and representatives of the British government.

Culminating a campaign of several years on the part of Secretary of the Interior Harold L. Ickes to claim for the federal government the oil underlying tidelands owned by the States, the United States on May 29 filed suit in federal court at Los Angeles to assert claim to a specific tract of 144 acres leased by California to Pacific Western Oil Company. The State will assist defense of the suit which is expected to go to the Supreme Court unless Congressional action makes the question moot. Not a new question to many Congressmen whose constituents are interested in tidelands, Congress by June 18 had 17 resolutions before it declaring the federal government has no claim to such areas. When hearings were opened on these resolutions officials of 46 States, either directly or in a consolidated brief, urged a House committee to approve legislation relinquishing all claims by the federal government to lands under coastal waters, lakes and rivers.

Ickes told the committee all the government wants is California oil lands.

Continuation of oil subsidies has been approved by Congress although members expressed belief that it will not be necessary to spend all of the $290,000,000 set aside for this purpose. This is the fund used to adjust for high-priced transportation, and PAW is of opinion that use of the expensive methods will continue high. The appropriations committee allowed PAW $4,950,000 for its next year of operation. This was a cut of nearly a million, but the committee's praise of the bureau was almost equal to a raise.

Office of Price Administration and spokesmen for smaller producers clashed again on the question of whether percentage depletion is an accepted method of accounting in the oil industry, and need for a ceiling price on crude oil which would reflect replacement cost. The argument was before the House small-business committee at a hearing called to learn (which it never did) why OPA's production-cost study has been so long delayed.

Without hearing and without argument, the House ways and means committee approved and the House passed a resolution placing Congress on record as meaning that the option on intangible drilling costs should be a permanent part of the tax statutes. This would cure a situation raised by a court decision holding against this option, and which has threatened the volume of well drilling.

Pending in the Senate, it has committee approval and passage would not require Presidential approval.

The Enemy Oil Committee has ceased operations, having completed extensive and detailed studies of oil fields, refineries and other oil installations held by the enemy to the end that they might be more effectively attacked by the air forces.

Use of residual oil as paving material has been prohibited by PAW. It was explained there have been large increases in requirements of the Navy and Merchant Marine, and inventories are at the lowest since the war began.

Discussions at the Interstate Oil Compact's meeting at Oklahoma City June 14-16 were devoted to natural gas. Federal regulation was scored, and it was pointed out that a greater market and higher prices would automatically result in conservation. Louisiana spokesmen, however, were not in accord on federal regulation, favoring Federal Power Commission restriction of interstate movement of gas. Other states also have officials who contend gas should be used in place.

OPA is preparing to boost the price of carbon black (probably 5 cents per pound) as a forerunner of an increase in the price paid by black manufacturers for gas. Gas producers contend they need a higher price but lack substantiating statistics. OPA will go at the matter backward and give them an increase on the ground that black producers received one.

War Production Board, in removing restrictions on use of carbon black, effective June 15, announced that this action reflected improved supply. This means that use of black will be permitted with limitations in effect prior to Ferruary 10 when drastic regulations were imposed which had the effect of lowering quality of tires made for civilian use.

Senate Oil Investigation Broad Attempt To Formulate United States Oil Policy

Representatives of the industry and spokesmen for government bureaus appearing before the Senate Oil Investigating Committee which began hearings June 18, under chairmanship of Senator Joseph C. O'Mahoney of Wyoming, for the purpose of outlining a national oil policy, were agreed on the desirability of such consummation. There, as is usual in such cases, agreement ended. Each representative and each bureau had their own ideas, which agreed only in division —opinion from the industry that it should be let alone; and insistance by the bureaus that unless the government takes an active part there will be national calamity and international chaos.

Still Enough Oil

J. Edgar Pew pointed out that in the past five years 7,320,000,000 barrels have been produced, while during the same time proven reserves increased from 18,483,012,000 to 20,453,231,000 barrels.

E. DeGolyer said gas reserves are in the nature of 200 trillion cubic feet.

M. G. Cheney, president of the American Association of Petroleum Geologists, testified that 1,049,000 square miles of the United States, not including the Atlantic Coast region and offcoast areas, all of which have definite oil possibilities, remain to be thoroughly explored.

Pew said he found no substantiation for contentions that domestic oil resources are threatened with rapid exhaustion, and that "assertion that at current consumption we are only about 14 years away from an oil famine is based on a misunderstanding of the facts." Oil always has been discovered and produced when and as needed, and when conditions justify the cost of such development, he said.

"There always will be enough oil for the Navy," Pew said in an analysis of Naval Reserves, "as long as there is in this country the amount of oil it needs, as it would have first call on any production. The setting aside of these reserves does not create any more oil, nor does it add anything to the strategic position of the Navy. If the experience of the Army . . . in connection with the

NEW! The EDWARD Intex UNIVALVE*

Newest addition to the Edward steel valve line, the Univalve is a forged steel globe valve for service to 1500 lb at 950 F. Body and bonnet are a single unit, the seat is integral with the body, and the inclined stem design and streamlined flow contours cut pressure drop to from 25% to 50% of that of most forged steel globe valves.

All the distinctive standard features of Edward valve construction are included—oversize knobbed handwheel, extra-deep stuffing box and cooling chamber, re-enforced EValpak molded packing, junk ring EValized for abrasion resistance, centerless ground EValloy stem—with the addition of many new features that make the Edward Univalve the best buy possible for high temperature, high pressure service.

**Integral seat valve with body and bonnet a single unit.*

1 WELDED BONNET

Patented leakproof welded body-bonnet joint, with backseating joint for repacking under pressure, and designed for disassembly if ever necessary.

2 INTEGRAL hard-faced SEAT

A continuous ring of Stellite applied directly to the body, machined in the same set-up with body bore for perfect alignment, and carefully mated to disk for full bearing area.

3 HARD FACED DISK

Heavy layer of ground and lapped Stellite on alloy steel disk.

4 BOLTED GLAND

Easy packing adjustment, with through-bolted, accurately guided gland.

5 BRONZE YOKE BUSHING

Minimizes wear and prevents galling.

6 ONE PIECE, Integral YOKE BONNET

Perfect alignment of working parts.

7 LOW PRESSURE-DROP FLOW

Edward inclined stem globe valve construction eliminates sudden changes of flow, reduces erosion-producing turbulence, and cuts pressure drop to minimum, yet retains desirable characteristic of globe valve tightness.

UNIVALVE SIZE RANGE
1500 lb —950 F
Screwed Ends
Fig. 2220—½", ¾"
Fig. 3220—¾", 1", 1½", 2"
Socket Welding Ends
Fig. 2224—½", ¾"
Fig. 3224—¾", 1", 1½", 2"

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is only as good as its
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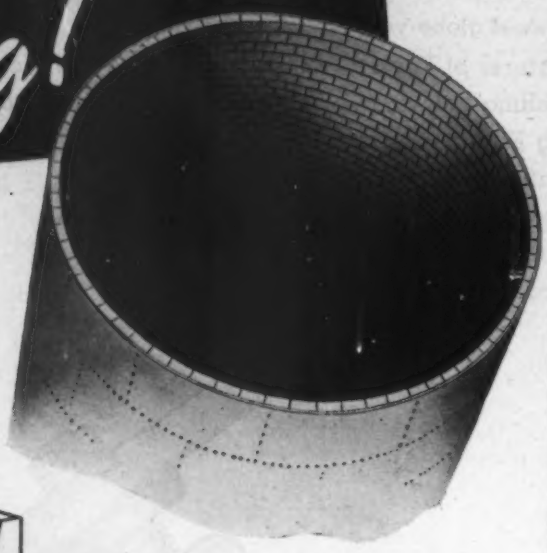

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● The best steel construction is of little value in an acid tank unless it is protected by an acid and leak proof lining. That's the reason so many refiners insist on NUKEM acid-proof brick, jointed with NUKEM acid-proof cement, for the linings of their processing and acid tanks of all sizes and shapes.

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THE MONTH...

Canol project . . . is any criterion, the Navy would have to spend probably billions of dollars to develop the oil for its requirements."

DeGolyer explained that gas discoveries, with few exceptions, are incident to the search for oil. For that reason resources are little known. Deeper prospecting for oil is likely to develop even greater gas resources, since proportion of gas to oil increases with the depth of hole. Gas, he said, is just coming into its own as a raw material, and "the time is not far distant when 10,000 cubic feet of natural gas may be regarded as a potential barrel of gasoline. If my speculation that, broadly speaking, discovered gas reserves may be regarded as being of the order of magnitude of 200 trillion cubic feet is not too unreasonable, they well may be of even greater importance than proved oil reserves, although it is clearly realized that only a portion of the gas reserves are likely ever to be used for conversion to liquid hydrocarbons."

Against Federal Control

J. C. Hunter, Texas representative on the Interstate Oil Compact, and E. Holly Poe, former PAW director of natural gas and natural gasoline, made pleas for relinquishment of federal control over the industry's operations. "The States," Hunter said, "ask and expect complete relinquishment of all federal regulations or control over the industry beyond the specific limits of interstate commerce." To this Poe added "Any extensions of federal power . . . would have to be made with gravest consideration for the varied rights of the States affected."

Definite Policy Wanted

John M. Lovejoy asked for the industry a definite federal oil policy, and decried the trend toward government-industry partnership as advocated by some in government and exemplified by Petroleum Reserve Corporation which he said should be abolished (forthwith), along with PAW as soon as the war is over, and "PIWC represents a type of 'government-industry' partnership to which many in the industry are opposed."

Plea for a consistent tax policy was made by F. B. Plank of Cities Service Oil Company, who emphasized need for continuance of percentage-depletion deductions and option on intangible drilling costs, while Walter S. Hallanan, president of Plymouth Oil Company, launched an attack upon OPA and its handling of crude-oil prices. A. C. Mattei, president of Honolulu Oil Corporation, attacked the public lands situation and the 25 agencies which have to do with government-owned lands.

Navy Reserve Insurance

Captain W. G. Greenman, director of Naval Petroleum Reserves, indicated the Navy merely considers them a form of insurance in the event of an emergency. He did not, however, indicate how the Navy plans to make the oil actually available for ships, although he reviewed plans for investigations which would disclose the Naval reserves as being of greater magnitude than now estimated. He praised the industry for supplying oil

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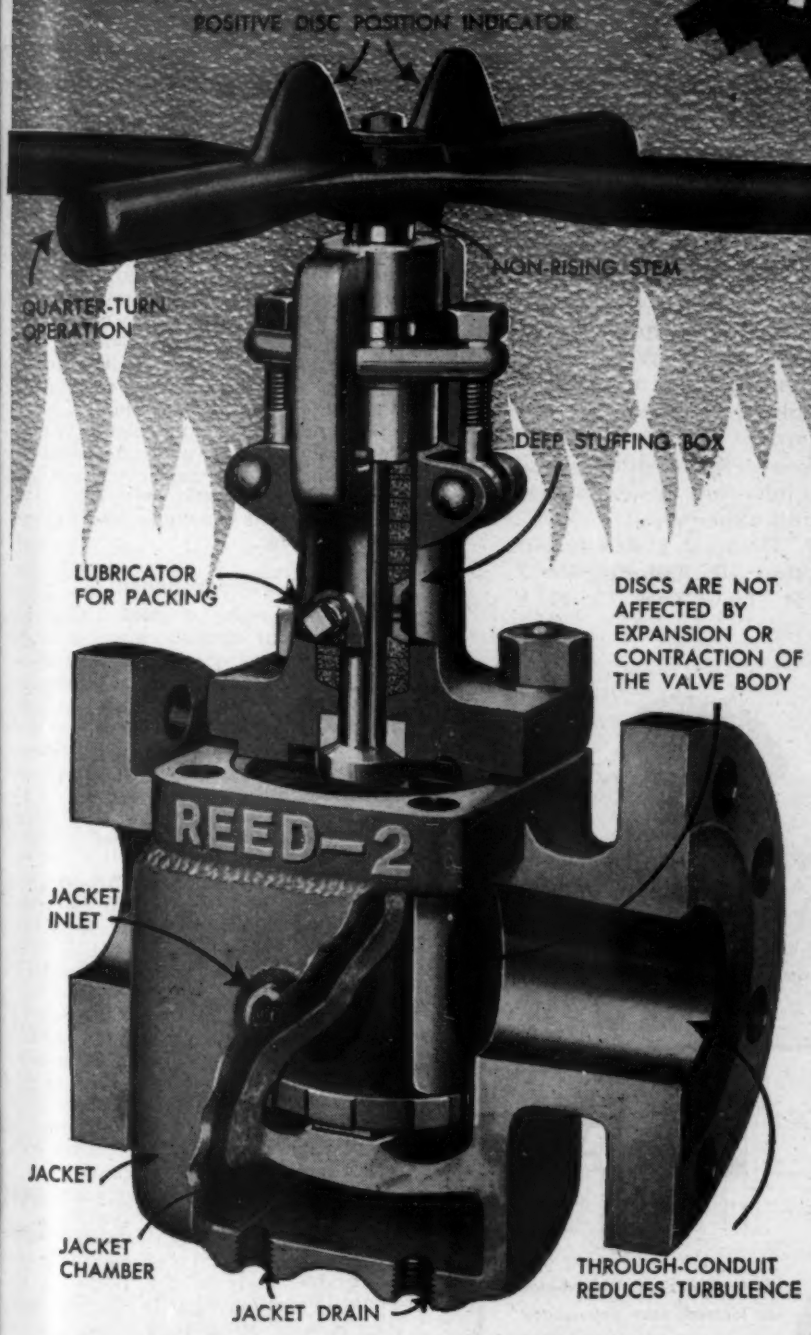

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The effective jacketing design of the Reed Jacketed Steel Valve, plus the easy operating features and cleaning action of the discs, assure dependable operation.

Reed Valves do not require lubrication and maintenance costs are negligible.

Expansion and contraction due to temperature changes, do not affect the action of the Reed Valve discs, which are accurately guided by the disc holder, yet are free to float with respect to the holder and the body seat.

REED JACKETED STEEL VALVES ARE INTERCHANGEABLE WITH WEDGE STEEL VALVES AND ARE SUPPLIED WITH A. S. A. STANDARD FOR O. S. & Y. WEDGE GATE VALVES.

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TIGHT VALVES CONSERVE FUEL

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Fig. 123 "N-M-D" Globe (Non-Metallic Disc)
Fig. 2125 Bronze Gate
Fig. 16 "Renewa" Globe
Fig. 1640 "King Clip" Gate
Fig. 1430 Iron Body Gate

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BRONZE, IRON, STEEL AND CORROSION RESISTANT ALLOY VALVES, 125 TO 2500 LB. S. P.; BOILER MOUNTINGS, LUBRICATING DEVICES, AIRCRAFT FITTINGS

THE MONTH...

for the current emergency and bespoke a continuation of that cooperation.

Speaking for the Army, General H. L. Peckham, War Department oil liaison officer, indicated the Army would prefer to look to the industry to supply its oil. He sees need for reserves of oil within the country but deems it impractical for government agencies to set aside and develop such a reserve.

Bureau Disagrees on Estimates

Michael W. Straus, assistant to the Secretary of the Department of the Interior, reported that the Bureau of Mines is producing liquid fuels from oil shale and coal, and explained that it did not go into obtaining liquid fuel from natural gas because it believes this is a field where industry will not need government assistance. The bureau is not convinced that such use of natural gas is a superior use, and anyway he sees only a seven-year supply of liquid fuel. He said the work on shale and coal is to provide a jumping off place for industry in that development when petroleum supplies are exhausted, and while he would not say when that will be, he did not agree with more optimistic estimates of the supply depicted by others who appeared at the hearing.

Foreign Policy

"A strong foreign policy that fully recognizes our national interest in each of the oil areas of the world and promotes a program of action commensurate with our national responsibilities and our future security" is the aim of the State Department, Charles E. Rayner, petroleum adviser to the department, told the committee. He said the Anglo-American agreement, eventually to be a multi-lateral pact, is designed to implement that policy.

Rayner estimated that American interests control 10⅛ billion barrels of known oil reserves outside the United States, British-Dutch control 12¼ billion, Russia 6 billion, and other nationals 2½ billion.

"Our commercial policy," Rayner said, "has never contemplated establishing conditions which would be injurious to efficient domestic industry. In our great home market there should be ample opportunity for the maximum efficient use of the capacity of our petroleum industry. Increased imports cannot be injurious to domestic industry producing at its maximum efficient capacity."

Chairman O'Mahoney noted recurrence of the word "efficient" in that paragraph, and on the point of who would determine what is efficient operation, pointed out that in some countries small groups set themselves up to determine such matters.

Charles W. Hamilton, a vice president of Gulf Oil Corporation, told the committee that American interests own or share in reserves in 20 foreign countries, are engaged in exploration in 11, and do not share production or reserves in 19.

Edward F. Johnson, general counsel for Standard Oil Company (New Jersey), criticized past policies of the State Department, and said that while operating programs of American companies

abroad should be in accordance with clearly defined policies of the government, they should in turn receive its wholehearted backing.

In recent years, Johnson indicated, the department has been active in its support of the industry. In Iraq and Netherlands East Indies, it has made it possible for Americans to share in production; it has been less successful in Argentina and Uruguay. It has been able to accomplish little in Chile, Brazil, Bolivia or Mexico. In Venezuela, he said, "the climate is now favorable."

While in the Middle East and Netherlands East Indies Americans fared "acceptably," he said, "on the other hand, there are some countries with oil-producing possibilities from which Americans are either barred outright or are faced with inhospitable laws. In India and Burma the door is closed to them. In China and the Philippines the laws favor their nationals to such extent that Americans are not likely to participate in development there until such laws are changed, though in these two countries marketing operations were carried on successfully for many years prior to the war."

Policy Recommendations

Johnson said that more specific recommendations on national oil policy will be subsequently submitted, but that generally the industry recommended the following broad policies:

That a national oil policy be developed by Congress;

That in relations between the Department of State and the industry, it is important that there be mutual understanding, confidence and close cooperation;

That the backing of the industry by the government be proclaimed;

That all foreign oil matters be centralized in the State Department as soon after the end of the war as may be appropriate; and

That treaties between this country and other oil countries definitely establishing mutual rights and obligations be negotiated.

Johnson also told of special problems created by the war, particularly the taking of oil by Rumania from the subsidiary of an American company, for delivery to Russia in payment of reparations, for which it is paying in depreciated local currency.

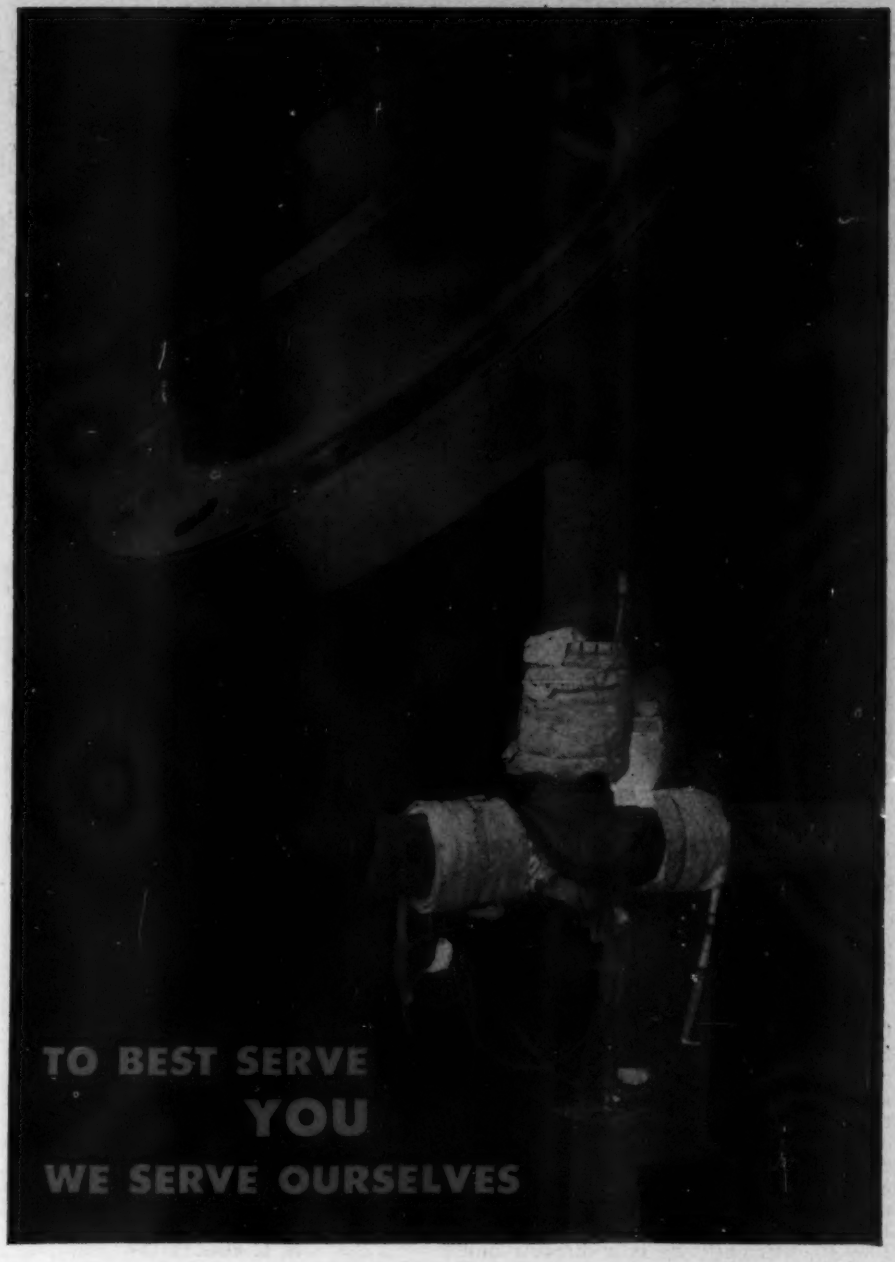
Five Promotions Announced By General Petroleum

P. S. Magruder, who was manager of the gas department has been appointed assistant manager of manufacturing for General Petroleum Corporation.

H. L. Eggleston, formerly with Gilmore Oil Company, has been named manager of the gas department and will continue to manage the manufacturing activities of Gilmore Road Oil and Asphalt Company.

M. W. Kibre, superintendent of the gas department at Vernon, has been named assistant manager of the gas department.

H. A. Sting, gas engineer at Vernon, has been appointed superintendent of the



Most industrial piping fabricators depend upon outside sources for flange requirements. Not so with Associated. Since we manufacture flanges we are in a position to supply the needs of our fabrication division at all times . . . and quickly. That is one reason why Associated jobs progress more rapidly, efficiently. What is equally important, it costs our customers not one extra penny to receive this EXTRA benefit of Associated service.

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ASSOCIATED Progressive PIPING

THE MONTH . . .

P. S. MAGRUDER

gas department, Southern Division, with headquarters at Vernon.

A. C. Lyles has been promoted from chemist at the Santa Fe Springs gas laboratory to gas engineer in charge of the "Springs" gas laboratory.

Magruder joined General Petroleum Corporation November 1, 1925, as gas tester at Vernon, subsequently was promoted to gas engineer; next, to general superintendent; and then to manager of the gas department. He is past president of the California Natural Gas Association, of which he was one of the organizers, and served as chairman of the technical committee of the association in 1936-39, before serving as president in 1939-40. Currently he is a director and member of the executive committee of C.N.G.A. and is a member of several committees for PAW District 5.

Eggleston joined Gilmore Oil Company November 20, 1928, as manager of the gas and refining departments, a position which he held continuously to the time of the company's consolidation with General Petroleum Corporation. Eggleston has been active in local and national affairs of the American Society of Mechanical Engineers. He was elected a member of the executive committee of the Los Angeles Section in 1935, and chairman in 1936. He helped organize California Natural Gasoline Association, has served on the executive committee since 1926, was vice president in 1928, 1929 and 1933, and served as president in 1934. He is a member of the Society of Automotive Engineers, and Yale Engineering Association.

Kibre is a graduate of the University of California, and joined General Petroleum Corporation in June, 1929, as a laboratory man at Santa Fe Springs. Subsequently he was promoted to chemist at Santa Fe Springs, then advanced to an engineer at Vernon in the gas department, being named superintendent of that department January 1, 1943, and general superintendent November 1, 1944, now becoming assistant manager of the department. He has served on the technical committee of the California Natural Gasoline Association since 1936, was vice chairman in 1939-40, and chairman of the committee during 1940-41. He also served on the American Petroleum Institute committee on sampling and natural gasoline.

H. L. EGGLESTON

Sting joined the company March 8, 1926, as gas engineer at Vernon, and in October, 1944, was named gas engineer at Santa Fe Springs. He is a member of the California Natural Gas Association, serving as a member of its charcoal test committee.

Lyles joined General Petroleum Corporation March 24, 1927, as gas tester in the gas laboratory at Santa Fe Springs, and in 1930 became chief chemist of the Santa Fe Springs gas laboratory. He resigned in February of 1934 to accept the post of gas engineer with the Kettleman North Dome Association, and was advanced to superintendent, leaving this organization in April, 1943, to become chemist at Santa Fe Springs laboratory. He is a member of California Natural Gas Association, currently on the editorial committee; has served on the technical committee for nine years and for five years was director of the association.

Jack T. Hanafin has been promoted from industrial lubrication engineer to contractor fuel and lubrication consultant for the Southern California division of the General Petroleum Corporation, it was announced by Frank Black, manager of commercial sales, Southern California Division. Hanafin has been with the General Petroleum Corporation for 13 years and before his promotion was serving as industrial lubrication engineer in the Colton area. While in that area he handled lubrication engineering for the contractors who built the Santa Fe Dam and the Prado Dam. Hanafin will make his new home in Los Angeles.

Crude Oil Runs to Stills, Production of Refined Products, and Stocks for the Four-Week Period Ending June 30, 1945

(Figures, in thousands of barrels of 42 U. S. gallons each, based on reports of American Petroleum Institute. Production and stocks include reported totals plus estimated amounts to make these figures on a Bureau of Mines basis)

DISTRICT	Capacity Percent Reporting	Crude Runs to Stills: Daily Average	Crude Runs to Stills: Percent Operating	Production: Gasoline*	Production: Kerosine	Production: Gasoil and Dist. Fuel Oil	Production: Residual Fuel Oil	Stocks at Refineries, Terminals and in Pipe Lines: Finished and Unfinished Gasoline	Stocks at Refineries, Terminals and in Pipe Lines: Kerosine	Stocks at Refineries, Terminals and in Pipe Lines: Gasoil and Dist. Fuel Oil	Stocks at Refineries, Terminals and in Pipe Lines: Residual Fuel Oil	Crude Oil: Daily Average Production	Crude Oil: Stocks†
East Coast	99.5	744	94.1	7,192	649	4,118	6,302	17,181	3,373	7,286	5,929	.....	.....
Appalachian District 1	76.8	103	72.5	1,335	231	336	376	3,017	250	346	264	.....	.....
Appalachian District 2	81.2	55	112.2	631	32	173	419	1,346	64	96	67	.....	.....
Illinois, Indiana, Kentucky	87.2	756	88.2	10,897	947	2,737	3,963	19,939	1,604	4,415	2,280	.....	.....
Oklahoma, Kansas, Missouri	78.3	392	83.6	5,825	666	1,874	1,881	9,455	795	1,818	1,245	.....	.....
Inland Texas	59.8	240	72.7	3,837	335	508	1,852	2,908	244	445	921	.....	.....
Texas Gulf Coast	89.3	1,207	97.6	15,493	1,720	5,665	7,005	13,647	1,537	6,032	6,024	.....	.....
Louisiana Gulf Coast	96.8	273	104.9	3,532	943	1,354	1,279	3,985	1,067	1,803	1,120	.....	.....
North Louisiana, Arkansas	55.9	86	68.4	965	220	298	519	2,624	185	670	172	.....	.....
Rocky Mountain District 1	17.1	12	94.2	153	18	30	94	86	20	21	36	.....	.....
Rocky Mountain District 2	72.1	123	79.7	1,587	72	384	931	2,370	108	322	529	.....	.....
California	87.3	948	92.8	9,854	353	2,631	12,699	13,914	429	8,959	21,901	.....	.....
Total U. S. June 30, 1945	85.8	4,940	90.9	61,301	6,154	20,108	37,320	86,472	9,676	32,213	40,488	4,903	220,974‡
Total U. S. May 26, 1945	85.6	4,849	89.7	60,446	5,928	19,152	38,164	89,121	8,246	29,184	38,548	4,887	222,831
Total U. S. July 1, 1944	.....	4,634	.....	.....	.....	.....	.....	81,984	9,825	35,242	52,769	4,587	228,860

* Includes natural gasoline blended at refineries. † Bureau of Mines. ‡ June 23, 1945.

ONE STANDARD ... Dependability

TO GET the right product in your hands at the right time is our business. We've been serving the Mid-Continent and Gulf Coast areas for 35 years. In that time we've learned that there is no business on earth where service means more than in the oil industry. And so we've built our business on that—we have the products you need—and we can get them in your hands quickly.

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NORVELL-WILDER
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A. M. Byers Company	Wrought Iron Pipe
Chaplin Fulton Company	Regulators
Dean Brothers Pumps, Inc.	Pumps
Hewitt Rubber Corp.	Packing, Hose
Hughes Tool Company	Valves
Kennedy Valve Mfg. Co.	Valves, Fittings
Ladish Drop Forge Company	Flanges, Forgings
A. Leschen & Sons Rope Company	Wire Rope
The Lunkenheimer Company	Valves, Steam Specialties
Merco Nordstrom Valve Company	Plug Valves
Pittsburgh Steel Company	Stainless Tubes, Still Tubes, Carbon, Moly Pipe
Quigley Company	Refractories, Insulation Material
Reed Roller Bit Company	Valves
Republic Steel Company	Line Pipe, Condenser Tubes
Strong, Carlisle & Hammond	Traps
Tube Turns, Inc.	Tube Turns, Flanges
Watson Stillman Company	Forged Steel Fittings
Victaulic Company of America	Couplings

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QUICK SERVICE
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THE MONTH . . .

Indiana Company Regroups Research-Development Staff

As part of the preparations of Standard Oil Company (Indiana) for postwar activities, a regrouping of its research and development staff was announced by Bruce K. Brown, vice president. The changes follow on Brown's recent re-election as a director and elevation to a vice presidency, and on the promotion of Joseph K. Roberts to the position of general manager of research.

In order to coordinate the research work more closely with that of other departments, two associate research directors have been moved from the Whiting laboratories to the general office in Chicago. While continuing his technical assignments, D. P. Barnard will also undertake liaison with the sales department with the aim of ensuring that the programs in research are consistent with consumer demands and needs and with the present and future trends in automotive and aircraft developments. Dr. Barnard is at present in Europe on an investigation sponsored by the Army Air Force. J. H. Forrester also will move to Chicago as general supervisor of technical service and product inspection activities for all refineries.

At the Whiting laboratories M. T. Carpenter has been appointed to the new position of executive director. A graduate of the University of Kentucky, he has been with the company for 15 years and had been an associate director of research since 1938.

R. C. Gunness has been raised from the rank of assistant director to that of associate director. Dr. Gunness received his doctor's degree from Massachusetts Institute of Technology in 1936, and spent two years on the faculty of the school of engineering practice before joining the company's research staff.

R. N. Giles, also an assistant director, has been promoted to the new position of superintendent of the technical service division. After graduate work at Ohio State in 1930, Dr. Giles spent four years at Casper refinery and was then moved to the research staff at Whiting.

A. B. Brown has become assistant superintendent in charge of technical service on heavy oils. He has been with the company since gaining his Ph.D. at Johns Hopkins.

C. R. Harte has been made assistant superintendent in charge of the work on light oils technical service and will also continue to supervise economic studies. After graduate work at Michigan and several years of subsequent experience in industry Dr. Harte joined the Indiana staff in 1936.

The two new heads of research and development activities arrived at their positions through training and experience in chemistry and chemical engineering. Brown did undergraduate and graduate work at the University of Illinois. After nine years' industrial experience as a chemical engineer and patent attorney he joined the company's staff in 1929. From 1942 to 1944 he had leave of absence to serve the government as assistant deputy petroleum coordinator and was the official chiefly responsible for the Petroleum Administration's stimulation of the nation's production of 100-octane gasoline. Roberts was graduated from the University of Kentucky in 1925, received a master's degree in chemical engineering from Massachusetts Institute of Technology in 1928, and has since been on the company's research staff. He became director of research in 1938.

BRUCE K. BROWN

DR. R. C. GUNNESS

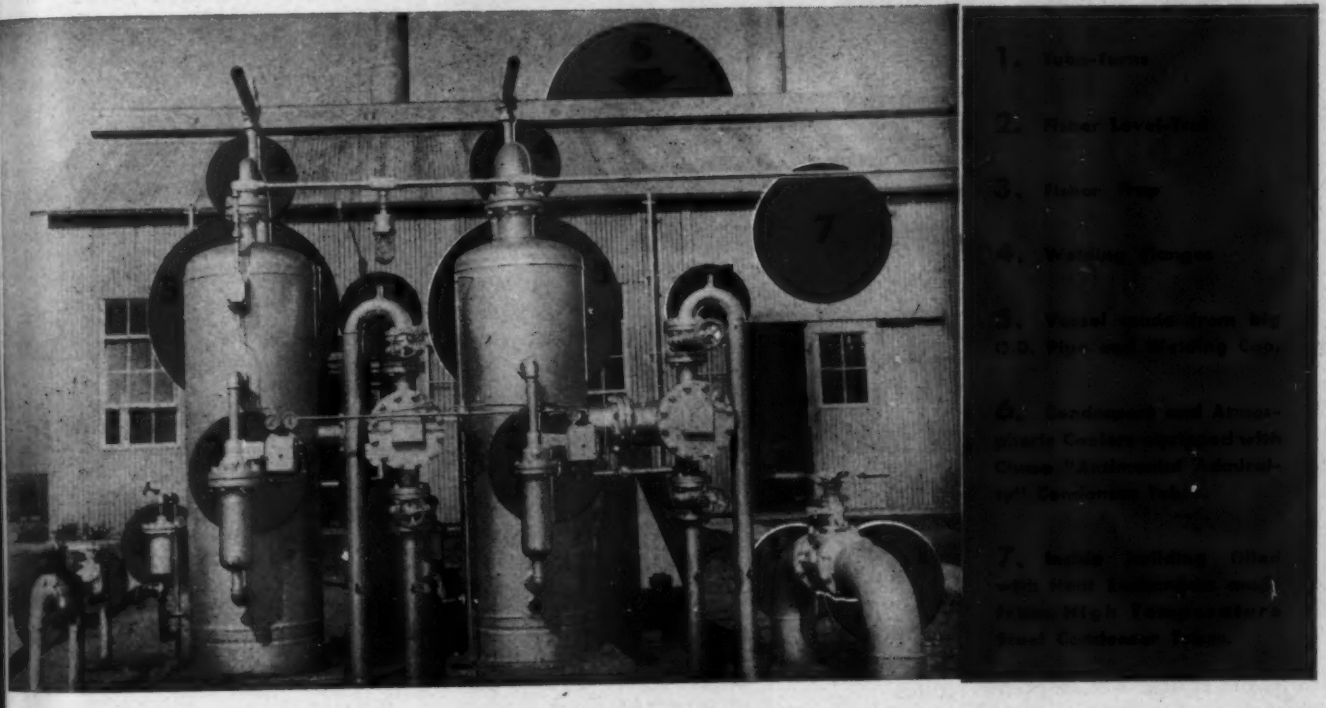
JOSEPH K. ROBERTS

M. T. CARPENTER

DR. R. N. GILES

Here's HOW Vinson SUPPLY COMPANY Fits in the Picture

All this Equipment was FURNISHED FROM STOCK by Vinson Supply Co.



Service that COVERS the Mid-Continent

Supply Headquarters for the Refiner

VINSON SUPPLY CO

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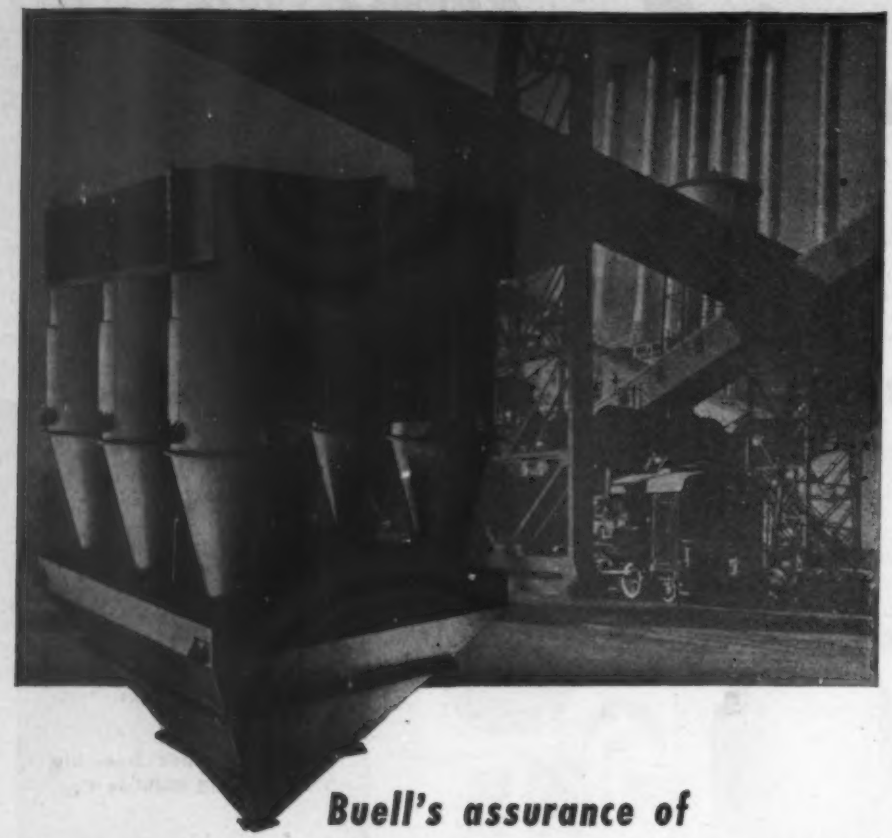

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HIGH EFFICIENCY, LOW MAINTENANCE, LONG LIFE

BUELL (van Tongeren) Dust Collectors have been in use for five or more years without a failure, without the replacement of a part. Many installations having been in continuous use under the most exacting operating conditions and at high working temperatures.

This recognized ability to withstand wear, heat and vibration is due to Buell's extra-sturdy construction. Fabricated of extra thick steel, completely seal-welded inside and out, with welds ground to a flush smooth surface, Buell bodies and cones are as "tight" as a casting. Buell hoppers, for example, have a reputation for especially rugged construction; braced and stiffened with 3" channels that offer strong resistance to vibration.

Finally, because Buell provides this *needed* ruggedness, Buell (van Tongeren) performance is always dependable.

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LARGE DIAMETERS
EXTRA-STURDY CONSTRUCTION
CORRECT HOPPER DESIGN
SPLIT-DUCT MANIFOLDS
INNER WELDS GROUND SMOOTH

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HIGH COLLECTION EFFICIENCY
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LOW DRAFT LOSS
LOW POWER CONSUMPTION
HIGH TEMPERATURE RESISTANCE
UNLIMITED CAPACITY
NO MOVING PARTS
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LOW MAINTENANCE
LOW OPERATING COST
LONG LIFE
NO CLOGGING

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Engineers and plant executives will find much of interest in Buell's 32-page book:
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DESIGNED TO DO A JOB, NOT JUST TO MEET A "SPEC"

THE MONTH...

Standard (New Jersey) to Rebuild European Plants

R. W. Gallagher, chairman of Standard Oil Company (New Jersey), told stockholders at their annual meeting that the company's high earnings are due to operation of facilities in the Western Hemisphere at maximum capacity and consequent efficiency. He expects the current demand to continue for at least the rest of this year. After the war, he said, "for a matter of at least a few years we will have some surplus of refining and producing capacity, as will probably be the case in the industry. We now plan to use this excess refining capacity in providing new and higher-quality products.

Gallagher said it now appears that the company's properties in Europe can be restored to operation, and that the reserves the company has set aside for reconstruction seem adequate.

"We are working and cooperating with the appropriate departments of government in reestablishing our properties and business in foreign lands as peaceful pursuits are resumed. We, like many other business concerns, face many problems in resuming our foreign trade. The answer to many of these problems will depend upon political and economic developments during the reconstruction period."

Plants in England, he said, are in quite satisfactory condition. In France the company sustained substantial damage. The lubricant blending plant at Rouen was destroyed and the refinery at Port Jarome, in which the company has an important interest, was 40 percent destroyed. In Italy apparently substantial damage was sustained from bombing of both refineries and distribution facilities. From Rumania the company has had little direct information, but it is known heavy damage was sustained by the refinery at Ploesti.

Eugene Holman, president of the company, Orville Harden, vice president, and B. B. Howard, director of the marine division, are in Europe to make an inspection of properties to appraise damages and rehabilitation possibilities.

Shell Starts Operation Of Allyl Chemical Unit

Shell Oil Company has put its new allyl unit in operation at its Houston refining plant. Both allyl chloride and allyl alcohol will be produced. The unit is the first in the United States for commercial production of the chloride product and the second to produce allyl alcohol. Products to be had from the two chemicals range from pharmaceuticals to new types of plastics.

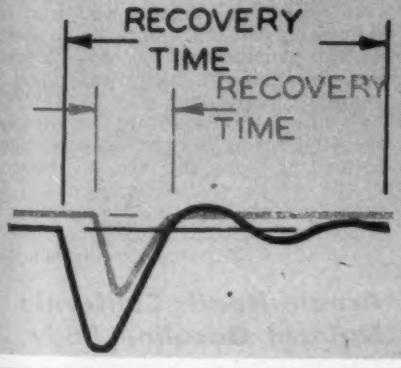
In releasing news of the new unit the company gave the following information on uses and prospective uses of the two chemicals.

"One of the chief uses of allyl chloride is the production of pain-easing drugs, including sedatives, hypnotics, diuretics and anaesthetics. Probably the best known of the allyl drugs is cyclopropane, an anaesthetic gas which puts the patient to sleep quickly and with a minimum of after-effects, since its high

Only INSTINCTIVE BALANCE *is quick enough*

When you're suddenly thrown off-balance, you have to ACT before you can get around to thinking. Such action is *instinctive*. Because it's instinctive, corrective action begins the instant the disturbance begins and this instinct adds just enough extra-corrective action to restore balance quickly and smoothly to avert further upset. That's INSTINCTIVE BALANCE!

In process control, HYPER-RESET provides balance that is truly instinctive. That's a great deal more than just instrument *alertness* to process disturbance. It's sensing the rate of disturbance at the very outset and instantly initiating not only a standard correction, but an additional correction precisely calculated for the particular process. This extra correction stabilizes the process in as little as one-fourth the usual time.



You can see the difference in recovery time right in stabilization curves of one typical process, below. The compound curve in black represents best possible process stabilization *before* HYPER-RESET. The simple, brief curve in green shows recovery *with* HYPER-RESET in the Foxboro Stabilog Controller.

Although fully satisfactory for some processes, the recovery in curve No. 1 might permit serious upsets in others. The patented HYPER-RESET function in Stabilog Controllers "feels" the requirements of each process, and precisely meets them. Write for detailed discussion. **The Foxboro Company, 74 Neponset Avenue, Foxboro, Mass., U.S.A.** Branches in principal cities.

Why HYPER-RESET Saves a Needless, Extra Adjustment

With a HYPER-RESET Stabilog Controller, *only one adjustment* is required for accurate selection of both the reset rate and the rate-sensitive, extra-corrective function.

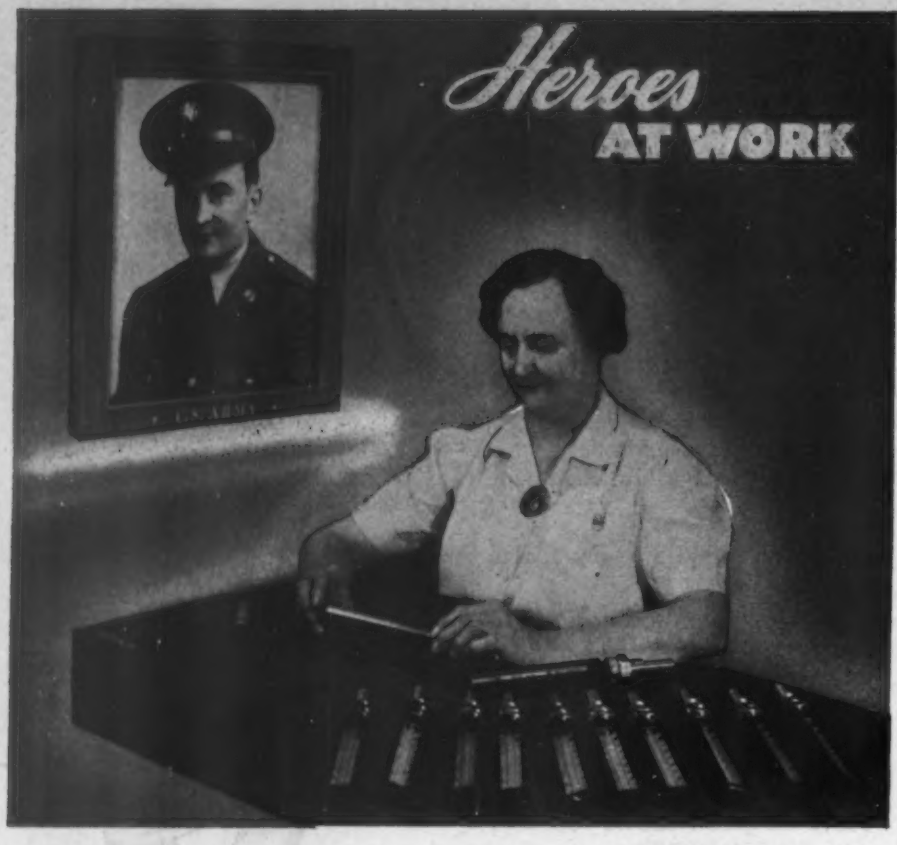
It has been well established that the response characteristics of a process determine how much correction can be applied, and how fast. It is the time characteristic which determines the reset adjustment. And it is this self-same time characteristic which also establishes the amount of rate-sensitive action required!

Both research and field experience have demonstrated that the rate-sensitive adjustment, as well as the reset, must be matched to the process; and that a definite relationship exists between any given reset value and the corresponding rate-sensitive value for best recovery.

These two values are combined as a *single adjustment* in the Foxboro HYPER-RESET Stabilog Controller.

FOXBORO Stabilog Control

REG. U.S. PAT. OFF.



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And together they do a grand job. For Mom is on the job, every day, inspecting each thermometer before it can be shipped and nothing gets by her eagle eye. It's folks like this, who are imbued with a spirit of loyalty to our firm, who are responsible for the fine Thermometers that help you to make a finer product.

Remember, in post-war plans, only Good Thermometers should be considered in rebuilding your future sales.

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THERMOMETER

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Makers of Industrial Recording and Laboratory Thermometers
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THE MONTH...

potency permits the administration of large amounts of oxygen.

"Allyl chloride is also the raw material for a vasoconstrictor drug used in the treatment of colds, allergic rhinitis, hay fever and sinusitis, particularly as they affect aviators.

"In addition to its medical uses, allyl chloride is expected to be the starting point of a broad new field of plastics and resins based upon carbohydrates. Experiments on allyl starch have produced a coating material which, besides being exceptionally hard and strong, is resistant to heat and solvents. Although production of this material has remained in the laboratory stage, it is predicted that in time of agricultural plenty excess food crops may, through allyl chloride, be transformed into effective plastics and paints.

"Allyl alcohol opens the way to a new group of allyl resins which represent a new type of plastics. Reacting with other chemicals, allyl alcohol forms a liquid which hardens into a clear, transparent solid with a smooth, hard and glossy surface.

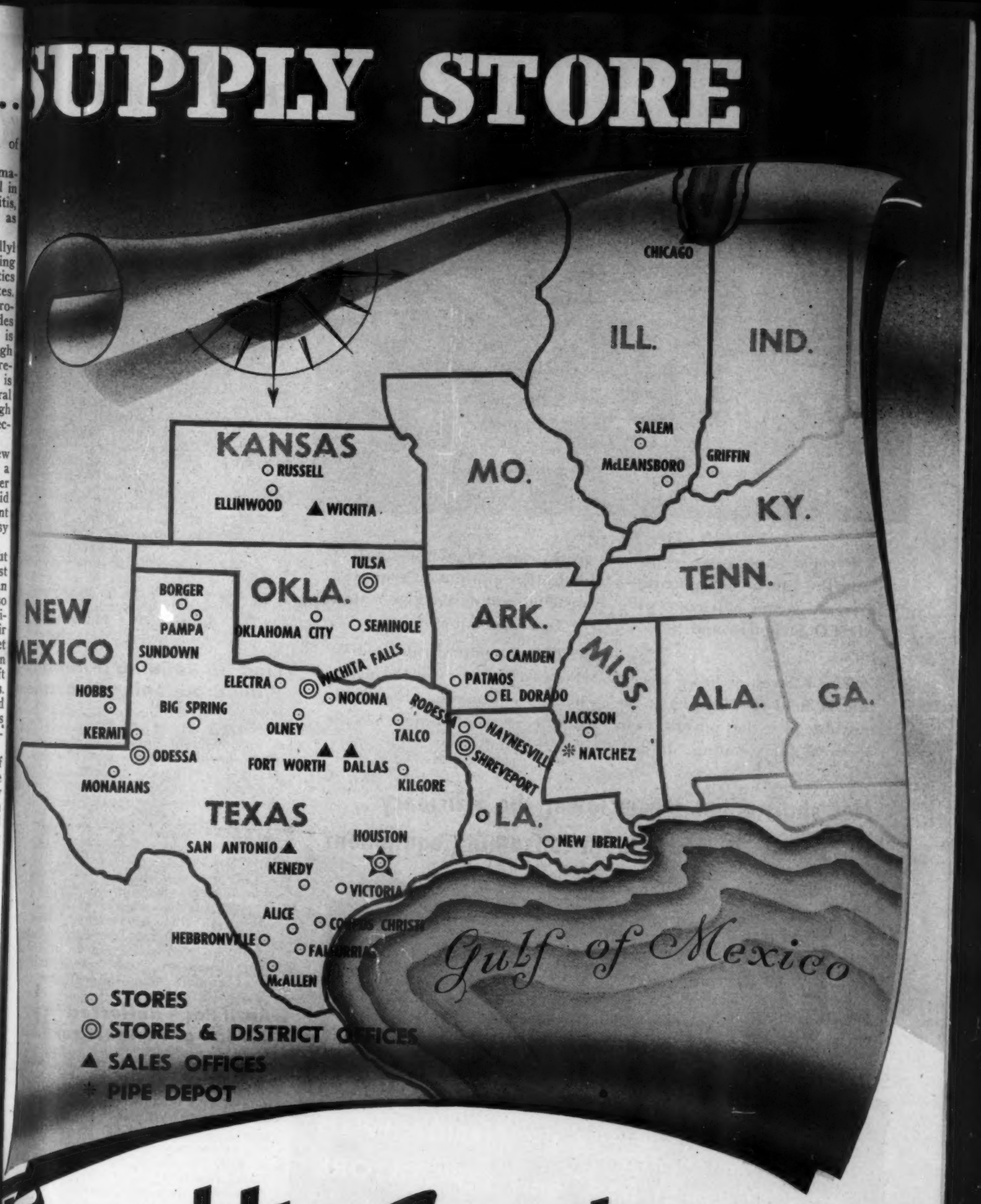
"Since the material is formed without the aid of the pressures needed in most plastics, laminates of the allyl resins can be made, not only in flat sheets, but also in complex curved shapes. These laminates are as strong, in proportion to their weight, as any structural material yet devised, and are now being used in making supports for self-sealing aircraft fuel cells, flak curtains and flak vests. After the war they may be in demand as wall paneling where color, cleanliness and resistance to heat, water and solvents are required.

"One of the important advantages of the allyl resins is that laminates can be formed without the use of the costly molds which would be needed if high pressure were required. Meanwhile, Shell engineers are continuing to explore the possibilities of the new twin chemicals."

Arnold Heads California Natural Gasoline Body

M. L. Arnold, Richfield Oil Corporation, has been elected president, and M. W. Kimbre, General Petroleum Corporation, vice president of California Natural Gasoline Association. Announcement of the secretary-treasurer will be made after the annual meeting scheduled for July 27. R. C. Enderly, Wilmington Gasoline Company, was added to the board of directors, his term to expire June 30, 1947. In addition to Enderly, directors include:

M. L. Arnold, Richfield Oil Corporation; A. H. Bell, Continental Oil Company; A. H. Bradford, West Coast Refining Company; J. A. Campbell, J. A. Campbell Company; L. V. Cassaday, Lomita Gasoline Company; F. J. Colton, Tide Water Associated Oil Company; F. E. Coyle, Tide Water Associated Oil Company; D. A. Cushman, Fullerton Oil Company; W. C. Dayhuff, California Research Corporation; F. F. Doyle, Pacific Gas & Electric Company; O. C. Field, Fullerton Oil Company; J. S. Fluor, The Fluor Corporation; M. L. Fort, Pacific Lighting Corporation; R. E. Foss, Barnsdall Oil Company; C. D. Gard,



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DIRT SHALL NOT PASS THRU ADSCO STRAINERS

Prevent shutdowns — prolong the life of equipment — increase steam efficiency with ADSCO Strainers and Separators.

The Y Strainer **has a screen that is held in place by a removable plug that permits easy removal for cleaning. It protects traps, regulators, valves and other equipment from the wearing and destructive action of foreign matter.**

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Nor shall moist steam lower the efficiency of your steam consuming equipment

ADSCO SEPARATORS

Remove oil and water from steam—increase its efficiency by delivering it dry.

***Right*—Horizontal Type**

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PROTECT VALUABLE EQUIPMENT ... INCREASE STEAM EFFICIENCY WITH ADSCO STRAINERS and SEPARATORS

AMERICAN DISTRICT STEAM COMPANY

NORTH TONAWANDA, NEW YORK

Makers of "UP-TO-DATE" Steam Line Equipment For Over 65 Years

THE MONTH...

Union Oil Company; R. D. Gibbs, Union Oil Company; R. W. Heath, Signal Oil & Gas Company; A. K. Hegeman, Clark Bros. Company; J. C. Herron, Shell Oil Company; M. W. Kibre, General Petroleum Corporation; W. A. Kirk, California Southern Oil Company; W. H. Kraft, Honolulu Oil Corporation; H. R. Linhoff, Richfield Oil Corporation; R. S. Lytle, operator; S. F. Magor, The Superior Oil Company; P. S. Magruder, General Petroleum Corporation; G. C. McLaren, Standard Oil Company of California; E. W. McAllister, Western Gulf Oil Company; Wm. Moeller, Jr., Southern California Gas Company; H. E. Moulton, C. C. M. O. Company; N. H. Mull, The Texas Company; H. W. Parmelee, Del Valle Gasoline Company; H. M. Paulsen, Bankline-Norwalk Company; W. L. Rifenberick, Industrial Engineers, Inc.; W. W. Robinson, Jr., The Texas Company; J. H. Sargent, Kettleman North Dome Association; W. D. Smith, Wilshire Oil Company; George Sowards, The Ohio Oil Company; T. L. Taggart, Standard Oil Company of California; J. B. Taylor, Signal Oil & Gas Company; R. S. Tulin, Shell Oil Company; J. B. Wharton, Belridge Oil Company; R. C. Wheeler, General Petroleum Corporation, and D. M. Wolfe, Standard Oil Company of California.

E. C. Spencer, The Norwalk Company, is chairman of the Taft chapter.

Lion Oil Refining Company Plans Broadening Operations

Lion Oil Refining Company stockholders have been called to meet July 2 to authorize enlarging its corporate powers to include manufacture of chemicals, plastics, synthetic rubber, and other products not usually included in the term petroleum products. Change of name to Lion Oil Company also is to be considered, along with an increase in common stock to provide additional funds for expansion.

The proposed changes would put the company in position to acquire the Ozark Ordnance Works at El Dorado, Arkansas, owned by Defense Plant Corporation and operated by Lion Chemical Company, a subsidiary of Lion Oil Refining Company. The ordnance plant produces ammonia from natural gas.

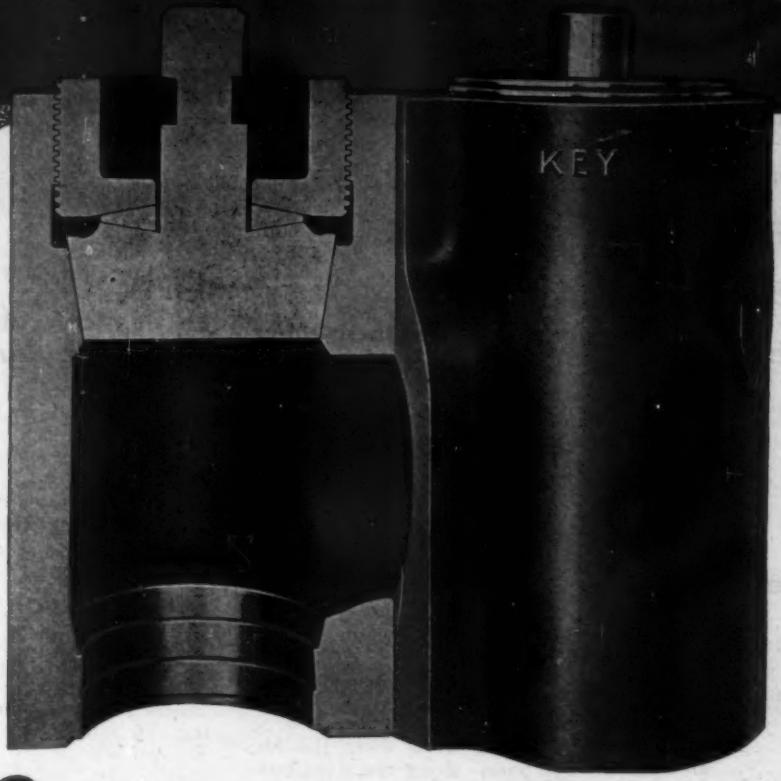
April Peak Reflected in Bureau of Mines Figures

April output of crude oil reached a peak of 4,801,000 barrels daily, an increase of 2000 barrels over the previous month, and while demand for domestic oil increased 83,800 barrels daily, it averaged only 4,792,700 barrels, permitting an increase in domestic-crude stocks of 8100 barrels a day, the Bureau of Mines reported.

Over-all demand, however, exceeded total supply, and stocks of crude, domestic and foreign, dropped from 229,644,000 to 229,555,000 barrels during the month.

Crude runs to stills increased 55,000 barrels to a daily average of 4,774,000 barrels. The gasoline yield dropped from 40.8 to 40.3 percent, but total deliveries of fuel were about 72,000,000 barrels, or 25 percent greater than in April, 1944

The Improved Key 7000 Type Return Bend Has Been Designed for Greatest Safety to Workmen and Equipment



Of all the known solid body type return bends, the Improved Key 7000 Type is the strongest. It is a balanced design giving best uniform distribution of stresses, which means no isolated weakness in design that would result in concentrated stresses in installation or operation.

The closure mechanism requires less wrench effort for tightening and results in a minimum of installation stresses.

The plugs may be loosened without removing closure parts, providing safety to workmen and protection of facilities found in no other design.

For *greatest safety, lowest cost, longest life,* and *lowest maintenance factor,* investigate the Improved Key 7000 Type Fitting.

We are **ENGINEERS . . . . METALLURGISTS . . . . MACHINISTS . . . . STEEL FOUNDERS . . . . FABRICATORS**

Send for bulletin describing Plug Pulling Procedure in detail.

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THE MONTH . . .

Total stocks of refined oils dropped 2,847,000 barrels to 220,443,000 barrels April 30.

The crude capacity represented in the report was 5,039,000 barrels, indicating an operating ratio of 95 percent, compared with 91 percent in April, 1944.

Synthetic-Rubber Needs Exceed Rated Capacity

Synthetic rubber must be produced at the 124 percent of rated plant capacity in 1945, and 145 percent in 1946 to meet the demand, according to S. T. Crossland of Rubber Reserve Company. His estimate is that 1,000,000 long tons will be needed in 1945, and 1,200,000 long tons in 1946. Production in the first four months of 1945 was 296,045 long tons.

Refinery Will Process Condensate at Carthage

Carthage Refining Company, headquarters at Houston, has underway construction of a 2000-barrel refinery near Carthage, Texas, to operate on condensate produced in the Carthage field, Panola County (East Texas). The plant is being built mostly with used materials, and plans call for operation by November.

E. C. Scurlock of Houston, head of Scurlock Oil Company, is president of Carthage Refining Company, and Alfred Glassell of Shreveport is vice president.

Abasand Plant Burns

Efforts to develop a commercial process for extraction of oil from the McMurray Tar Sands along the Athabaska River in Northern Alberta have been set back by a fire of unknown origin which caused an estimated $300,000 damage to the government-backed Abasand Oils plant and equipment.

The fire destroyed the 500-barrel experimental separation plant, machine and pipe shops and other equipment.

Heads Aviation Section

A. T. Hapke, Jr., has been selected to head the newly created aviation section of the American Petroleum Industries Committee. He recently has been market research manager for Republic Aviation Corporation. After graduating from Yale in 1933, Hapke was a pilot for Pan American Airways.

Motor Fuels from Farm Wastes

A process for the chemical conversion of such agricultural residues as corncobs, sugarcane bagasse, peanut shells, flax shives, oat hulls, and cottonseed hulls and burrs into liquid motor fuel and other commercially valuable products is moving into the semi-works stage of experimentation at the Northern Regional Research Laboratory, Peoria, Illinois.

Results of experimental laboratory investigations by Department of Agriculture chemists indicate that from 90 to 95 gallons of liquid motor fuel can be obtained from a ton of corncobs or cottonseed hulls, and that about half of this is in the form of ethyl alcohol. A continuous process for the treatment (or saccharification of corncobs and cottonseed hulls has given such promising results in the laboratory that the work is to be enlarged and evaluated on a semi-commercial scale.

Wooster College Honors Wagner With Doctorate

C. R. Wagner has been awarded the degree of doctor of science by Wooster College, from which he received B.S. in 1915. Wagner started as a chemist with Standard Oil Company (Indiana) in 1918, and after five years went with Lion Oil Refining Company as manager of refining. In 1924 he went with The Pure Oil Company where he advanced to chief chemist and chairman of that company's refinery control board. Since 1942 he has been a consultant. He has been active with the petroleum division of the American Chemical Society since 1929.

Pugh Made Assistant Superintendent at Lima

George B. Pugh has been appointed assistant superintendent at Lima refinery of The Standard Oil Company (Ohio). He started at Lima 20 years ago as a laborer, and having progressed through most of the operating jobs of the refinery, has been process foreman since 1940.

Elton Sterrett Secretary For Corrosion Engineers

Elton Sterrett has been appointed executive secretary of the National Association of Corrosion Engineers, with offices in the Southern Standard Building, Houston. For the past five years Sterrett was on the editorial staff of *The Oil Weekly,* and for nine years prior to that was assistant chief engineer for the Arkansas Pipeline Corporation at Longview, Texas.

G. L. Rowsey Heads Gulf Coast Refiners Association

G. L. Rowsey, Taylor Refining Company, Taylor, Texas, was elected president of Gulf Coast Refiners Association at the annual meeting at Houston early in June. Other officers, all re-elected, include John A. Bartlett, American Mineral Spirits Company, Corpus Christi, and George O. Irvine, American Republics Corporation, Houston, vice presidents; L. F. Rothermel, Maritime Oil Company, Houston, treasurer, and George Reid, executive secretary. M. S. McCorquodale is general council, and Norman L. Meyers is Washington counsel.

In addition to the above officers, the board of directors of the association now includes L. E. Vivien, Chalmette Petroleum Corporation, Chalmette, Louisiana; R. B. Kahle, Eastern States Petroleum Company, Houston; John Hamman, Jr., Hamman Oil and Refining Company, Houston; Edwin Singer, Great Southern Corporation and Pontiac Refining Company, Corpus Christi; J. E. Kelley, Republic Oil Refining Company, Texas City, and S. S. Seltzer, Jr., Southwestern Oil and Refining Company, Corpus Christi.

Great Southern Corporation, headed

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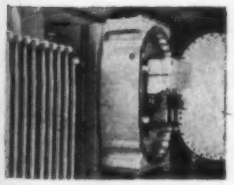
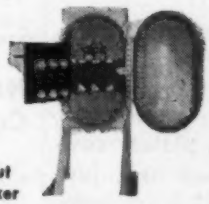
Our complete line of metal-enclosed unit substations enables you to benefit from

LOAD-CENTER DISTRIBUTION throughout the refinery

Have you been unable to take full advantage of the LOAD-CENTER SYSTEM of power distribution because of semi-hazardous conditions in certain parts of your refinery? It is in these locations that the benefits of load-center distribution are most needed. You will be glad to know that the complete line of G-E unit substations now includes units specially designed for use in semi-hazardous locations in refineries.

Each substation consists of a primary power circuit breaker or interrupter switch, a standard transformer section, a secondary bus enclosure, and any desired number of circuit breakers.





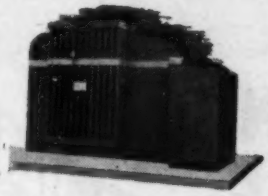
Swing open the cover

Swing out the breaker

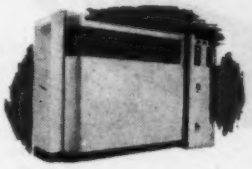
Air circuit breakers are easily removed for inspection or maintenance. Breaker enclosures are explosion-proof, with all arcing parts in enclosures for Class I, Group D, locations, as defined in the National Electrical Code. Adequate interrupting capacity is provided in these units. The insulating and cooling liquid in the transformer cannot burn or give off explosive vapors.

Completely factory-built, these units may be put anywhere, indoors or outdoors. In combination with standard G-E unit substations, they make it possible for you to set up a well-organized power system throughout the refinery, reducing voltage drop, and eliminating the danger of inadequate interrupting capacity. Before you formulate any plans for increased power supply, have a G-E application engineer show you additional data on the advantages of G-E unit substations for refinery use. *General Electric Co., Schenectady 5, N. Y.*

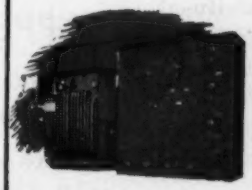
The G-E Unit Substation Family for Long-range Power Planning



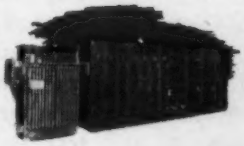
MASTER UNIT SUBSTATION. A complete packaged substation for multifeeder radial or network systems, with or without bus-voltage regulation. A metal-clad weatherproof enclosure around switchgear offers a high degree of safety to personnel. Units are available in sizes from 750 kva to 25,000 kva.



LOAD-CENTER UNIT SUBSTATION. G.E. offers units, in sizes from 100 to 2000 kva, equipped with either Pyranol* or dry-type transformers, depending upon your requirements. This unit substation for indoor service has a dry-type transformer.



D-C UNIT SUBSTATION. This d-c unit substation consists of completely metal-enclosed a-c switchgear, a transformer, and a metal-enclosed, sealed-ignitron mercury-arc rectifier with enclosed control, and d-c switchgear. Available in ratings of 75 to 500 kw at 250 volts and 100 to 1000 kw at 600 volts.



CONTROL-CENTER UNIT SUBSTATION. For centralized low-voltage control, a unit substation with Cabinetrol is recommended. Full-voltage, reduced-voltage, single-speed, multispeed, and reversing starters can be grouped and interlocked in any required sequence.

*Trade-mark reg. U.S. Pat. Off.

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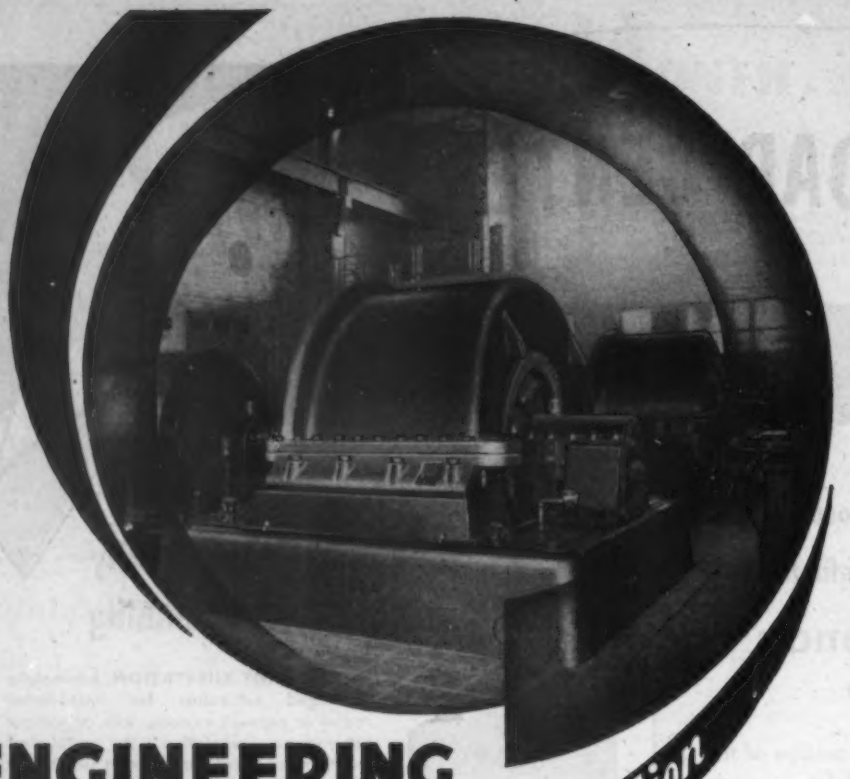

ENGINEERING EXCELLENCE

from inception to installation

Photo shows an installation of three 3-stage "R-C" Centrifugal Blowers. Capacity of each, 15,000 CFM, pressure 7.75 lbs., speed 3,565 RPM.

When you invest in an "R-C" Centrifugal Blower or Exhauster, you will find that every detail of construction has been given engineering consideration. Design effort has been expended on each part to assure its proper functioning with all other parts, and thus make the whole a masterfully engineered job.

An investigation of Roots-Connersville Centrifugal Units in action will convince you that their highly efficient and smooth operation are the result of engineering excellence—from the inception to the installation of the unit.

APPEARANCE

may not tell the whole story

A watch with 7-jewel works in a cheaply-plated case may look, when new, just as good as a 21-jewel works in a solid gold case. The true value shows up in performance—and time is the test.

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WRITE FOR BULLETIN 120 - B - 12

Roots Connersville Since 1854 Centrifugal EXHAUSTERS and BLOWERS

THE MONTH...

by Edwin Singer, who also is president of Pontiac Refining Corporation, was added to the membership of the association.

Rowsey is president of Taylor Refining Company which has refining and butadine operations at Corpus Christi, and of Coastal Refineries, Inc., which operates a refinery at Port Isabel, Texas. He has been identified with the petroleum refining industry for more than 25 years, and has built and operated several refineries throughout Texas. He has been appointed an ex officio member of Petroleum Industry War Council to represent the Gulf Coast independent refiners. He also is serving on the PIWC refining committee and on a number of committees of PAW in District 3, and on Committee 6 recently appointed by the Oil Industry Committee of Five.

Instrument Men Organize National Association

The Instrument Society of America was organized recently at a conference in Pittsburgh attended by delegates from 15 measurement- and control-instrument societies that have been growing in different industrial centers throughout the country. Purpose of the society is to advance the arts and sciences that are connected with the theory, design, manufacture and use of instruments. The society is open to both professional and non-professional men, and offers membership to any person, company or institution interested in its objective.

Pro-tem officers include A. F. Sperry, Chicago, president; C. F. Kayan, New York, vice president; C. E. Fry, Pittsburgh, treasurer, and Richard Rimbach, secretary. Committees were appointed to proceed with details of the organization. The office of the secretary is the temporary office of the society, and is at 1117 Wolfendale Street, Pittsburgh 12.

Hutchings Heads Southern California Meter Association

Southern California Meter Association at its regular monthly meeting, which brought together 250 members and guests for dinner and entertainment at Rio Hondo Country Club June 21, elected the following officers:

C. L. Hutchings, Tide Water Associated Oil Company, president; Lee Cheever, Southern Counties Gas Company, vice president; C. G. Cortelyou, General Petroleum Corporation, treasurer, and George H. Forster, Jr., The Texas Company, secretary. Mark McIlvaine, Chanslor-Canfield-Midway Oil Company, is past president. Committee chairmen selected include R. N. Christiansen, Southern California Gas Company, program; A. J. Norman, Southern California Gas Company, membership; W. L. Cowan, Union Oil Company, standards; Charles Meriam, The Meriam Instrument Company, publicity; George Stevenson, Pacific Meter Works, entertainment; W. J. Kennedy, Southern California Gas Company, by-laws; J. C. Groenewegen, Shell Oil Company, instrumentation, and R. T. Furlong, The Texas Company, San Joaquin Valley.

On the program for the association's

A sailor on a landing barge . . .

A watchman on a fire escape . . .

An engineer in a power plant . . .

A stevedore on a loading platform . . .

Every time he puts his foot *down*, forty Diamond Treads are there — reaching *up* to give him extra traction; to hold him against slipping in any direction. That is what "A.W." Super-Diamond Floor Plate means to workers in industrial plants, refineries, railroads, on ship-board. Easy to clean. Quick to drain. Toughest use will not damage it. Can be installed overnight without disturbing production. Write for catalog.

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A constant pressure of 75 psi. (saturated steam) is maintained on evaporator, unloading to feed water heater.

Because of the comparatively light weight and compact construction of R-S Butterfly Valves, less supporting structure and space are required. As a consequence, substantial savings in installation costs are effected. Simplified design and standardized construction mean lower first cost and ease of installation.

R-S Butterfly Valves are machined to close tolerances depending on temperature conditions. There is no tendency to jam or freeze. In any line, they sting the maintenance bill every time. Ask for Catalog No. 14-B.

No. 625. 150-pound three-way valve with air cylinder positioner control and adjustable linkage. Ideal for quick control and wedge-type shut-off in mixing and interchange service. Precision engineered, metallurgically and mechanically.

No. 608. Designed for either a high pressure drop and small volume or a low pressure drop and large volume. The large vane seats against the body of the valve while the smaller vane is free revolving. Four to six revolutions of handwheel completely open or close vane. Adapted to power operation.

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THE MONTH...

meeting July 19 are papers on "Measurement of Solids in a TCC Plant" and "Measurement of Solids in a Fluid Catalytic Cracking Plant," the first by A. E. Kelley of the process division of Union Oil Company, Wilmington Refinery, and the other by George Lewis, The Texas Company, Wilmington Refinery. These speakers will lead the discussion.

Flame-Thrower Research Workers Get Awards

Four research experts of Standard Oil Company (Indiana) refinery at Whiting, Indiana, who lost their lives in May last year by explosion of a flame thrower have been honored posthumously in certificates of merit presented by the Office of Scientific Research and Development. They were Frank V. Ovitz and James G. Nellis, chemical engineers; John Leonard, engine mechanic; and John J. Hanusin, engine laboratory foreman. Eight others who worked on the project received similar awards.

Forwarding the certificates to the widows of the four, Dr. Robert E. Wilson, chairman of the board of the company, said that "the contributions they made for victory were as real in every sense as those of our troops in battle. The development program on which they were working was of real importance in advancing the flame thrower to the important place on the battlefield which it occupies today."

The other eight honored included E. R. Barnard, assistant director of research, who is still convalescing in Florida from burns; Dr. T. H. Rogers, Dunes Acres, Chesterton, associates director, who sustained serious injuries; James A. Bock, 5 Waltham Street, Hammond, Indiana, chemical engineer; George Hajduk, 2347 New York Avenue, Whiting, technician; Bernard J. Lotkowski, 8831 Muskegon Avenue, Chicago, machinist; E. T. Molson, 1236 119th Street, Whiting, engine mechanic; W. A. Proell, 10630 South St. Louis Avenue, Chicago, chemist; and R. B. Terry, 7548 Coles Avenue, Chicago, chemical engineer.

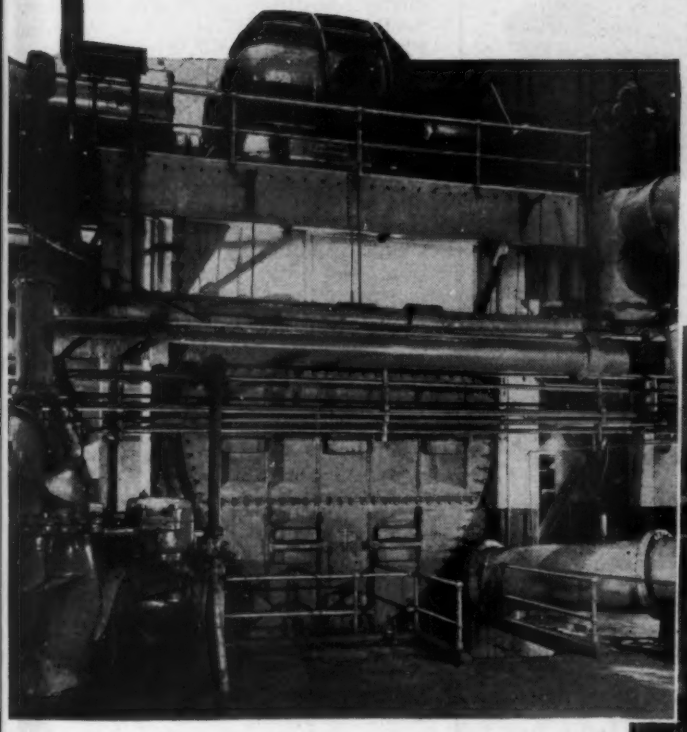
The flame thrower research was carried out by Standard Oil Company (Indiana) under the auspices of the National Defense Research Committee; and the awards were made in appreciation of effective service "contributing to the successful prosecution of the Second World War."

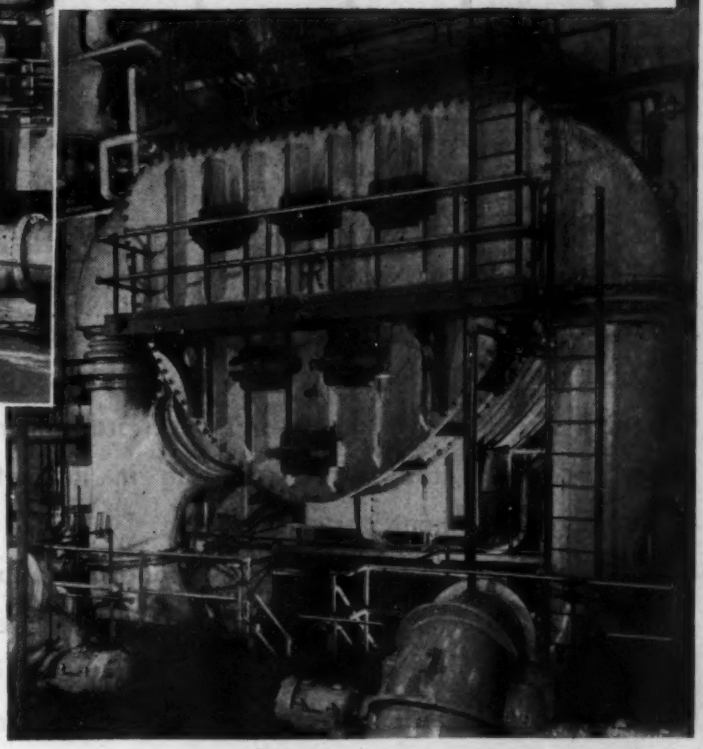
A. V. Ritchie Dead

Allan V. Ritchie, superintendent of The Texas Company's Beacon research laboratory since it opened in 1931, died of a heart attack June 19.

Ritchie graduated from University of North Dakota with a degree in mechanical engineering in 1910, and joined The Texas Company at Casper, Wyoming, as chemist and treater foreman. In 1925 he transferred to Port Arthur as chemist, and the following year moved to Lockport, Illinois. In 1928 he became an engineering chemist of the company's technical division at New York, where he remained until the Beacon laboratory was established. Had he lived until June 25

again--- *Anaconda Tubes* render Outstanding Service





Two condensers at plant of Buffalo Niagara Electric Corporation, equipped with Anaconda Condenser Tubes. Upper unit: Capacity 34,000 sq. ft.—7,282 tubes installed in 1926. Lower unit: Capacity 45,000 sq. ft.—6,850 tubes installed in 1930.

In 1926 and 1930, the condensers illustrated were equipped with a total of over 14,000 Anaconda Condenser Tubes. Except for a few, damaged while cleaning one of the condensers, these tubes are still in service.

This outstanding performance emphasizes the economy of selecting condenser tubes to meet specific conditions. As an aid to such selection, The American Brass Company offers a two-fold service: First, technical assistance based on years of study of tube metallurgy under a wide range of operating conditions. Second, a wide variety of specialized condenser tube alloys.

As a step toward taking advantage of this service, write today for illustrated Publication B-2, "Anaconda Tubes and Plates for Condensers and Heat Exchangers." 45124

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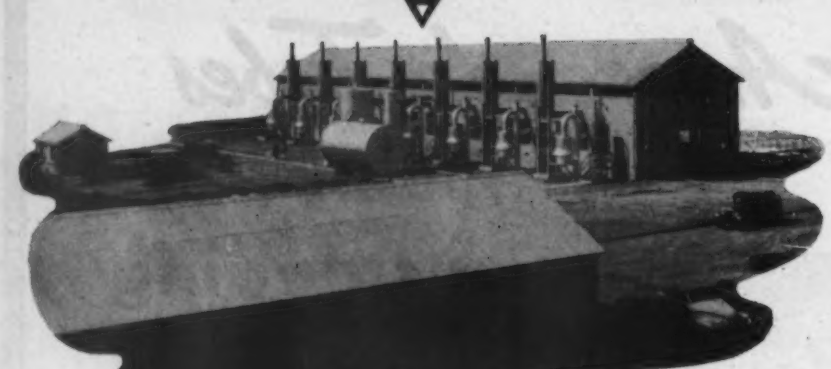

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Braden Sectional Steel Buildings, from Gate House to largest Warehouse, all have the same structural features and attendant advantages that make for LOW COST and LONG LIFE. Refinery buildings usually represent a sizeable investment—but deterioration and obsolescence take toll, often resulting in loss of entire building investment.

This is not true of Braden Sectional Steel Buildings. They can be erected, changed, or moved and re-assembled with low priced labor, for they are built from prefabricated standardized steel sections that are easy to assemble.

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THE MONTH...

he would have received from the Office of Scientific Research and Development an award in recognition of confidential research work connected with the war effort.

Ritchie was a member of the American Chemical Society, American Petroleum Institute, Society of Automotive Engineers, Society of the Plastics Industry, Institute of Radio Engineers, Society of Radiology, the American Physical Society and other similar organizations.

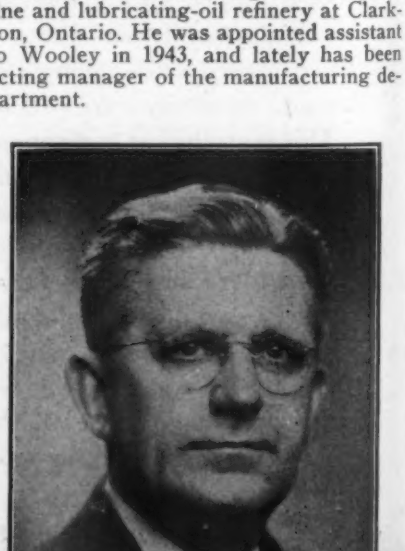
Stewart General Manager Bay Refining Company

R. W. Stewart has succeeded Edward W. Reiser as general manager, vice president and treasurer of Bay Refining Company and Bay Pipe Line Corporation, Bay City, Michigan. Reiser, who organized the companies in 1938, is retiring because of his health.

Beringer Heads British American Manufacturing

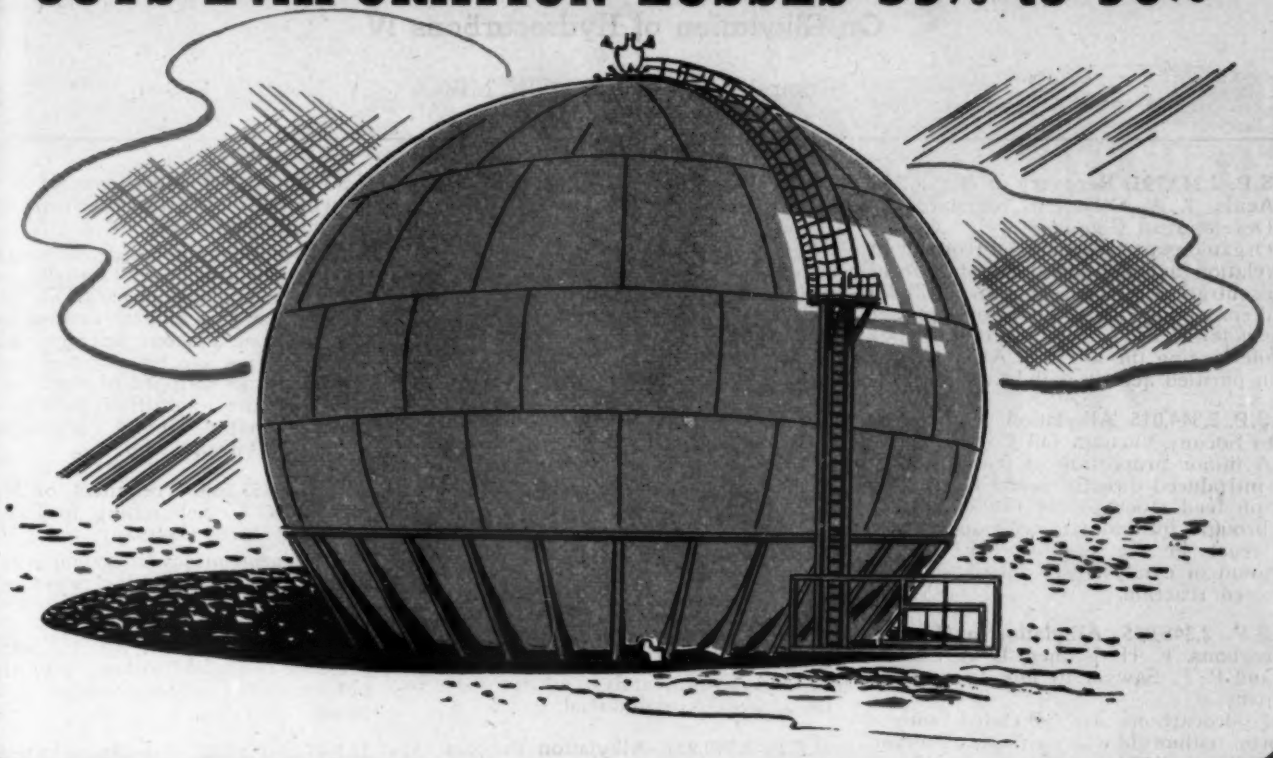
Milton S. Beringer has been appointed general manager of the manufacturing department of The British American Oil Company, Toronto, Canada, succeeding L. E. Wooley who has retired on account of ill health.

Beringer is a chemical engineering graduate from Texas A. & M. College, and had wide experience in refinery construction and operation in the United States and abroad before joining British American Oil Company in 1934, having been associated with the old Sapulpa Refining Company, Continental Oil Company and Arthur G. McKee & Company. He supervised construction of the company's Turner Valley absorption plant, Calgary refinery, Montreal refinery extensions, and the new high-octane gasoline and lubricating-oil refinery at Clarkson, Ontario. He was appointed assistant to Wooley in 1943, and lately has been acting manager of the manufacturing department.



MILTON S. BERINGER

CUTS EVAPORATION LOSSES 35% to 50%



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It's LIQUID ALUMINUM

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Be sure to insist on aluminum coatings of standard quality, made with Reynolds Aluminum powders and pastes free from corrosion-forming impurities. These superior pigments are made from purest Reynolds aluminum foil stock . . . rolled . . . flaked . . . polished for top brilliance and reflectivity . . . *quality-controlled* every step of the way from mine to pigment . . . and backed by a quarter century's experience.

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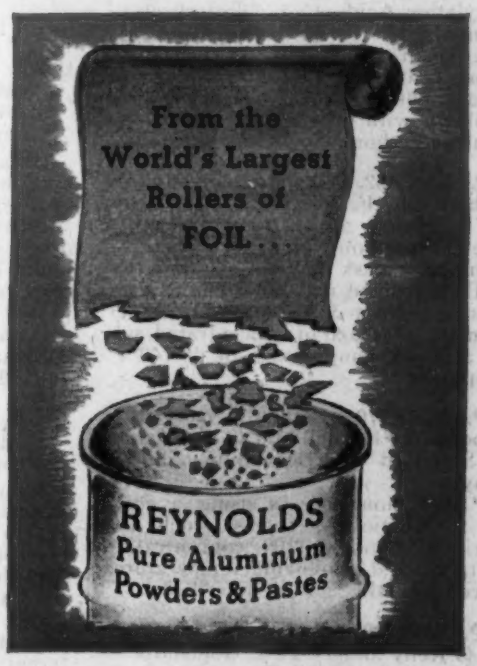

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REYNOLDS *points the way through* ALUMINUM POWDERS and PASTES

DIGEST OF UNITED STATES PATENTS

On Alkylation of Hydrocarbons IV

Compiled by HEINZ HEINEMANN

U.S.P. 2,343,791. Recovery of Alkylation Acids. J. A. O'Dell to Standard Oil Development Company.

Organic matter is removed from spent alkylation acid of about 85-92 percent concentration by diluting it to 30-40° Bé and contacting it with about one quarter its volume of petroleum acid sludge while heating the mixture. After separation purified acid is withdrawn.

U.S.P. 2,344,015. Alkylation. E. B. Allred to Socony-Vacuum Oil Company.

A minor proportion of fresh catalyst is introduced directly to the fresh alkylation feed stock before the feed stock is brought into contact with and caused to react in the presence of the full amount of catalyst used for causing the desired reaction.

U.S.P. 2,345,095. Alkylation of Hydrocarbons. F. H. Bruner, L. A. Clarke, and R. L. Sawyer to The Texas Company.

Hydrocarbons are alkylated with a boron-trifluoride water complex containing about 21-29 percent by weight of water.

U.S.P. 2,345,506. Regeneration of Spent Alkylation Acids. O. C. Slotterbeck to Standard Oil Development Company.

The spent acid is diluted to 40-60 percent, heated above the boiling point of water but below that of dilute acid and blown with air and steam to form flocculent carbon which is separated.

U.S.P. 2,346,452. Alkylation of Hydrocarbons. E. F. Pevere, L. A. Clarke, G. B. Hatch, and F. H. Bruner to The Texas Company.

A molar excess of a low-boiling isoparaffin is reacted with an aliphatic alcohol having from 3 to 10 C atoms per mol in the presence of concentrated sulfuric acid. A temperature of 45-140°F. is employed.

U.S.P. 2,346,770. Catalytic Alkylation Process. P. Lobdell and G. L. Mateer to Standard Oil Development Company.

An alkylation process using a complete C_4 fraction as charge stock and sulfuric acid of 80-1100 concentration as catalyst and employing temperatures between 15 and 125°F. is described.

U.S.P. 2,347,790. Alkylation Process. A. A. O'Kelly and D. P. J. Goldsmith to Socony-Vacuum Oil Company.

The catalyst used consists essentially of solid material selected from the group consisting of compounds of the general type MX and associations between such compounds, wherein M is a metal and X is chlorine, or fluorine and MX is a metal halide that is a solid stable compound at 800°F.

U.S.P. 2,348,467. Alkylation of Hydrocarbons. A. R. Goldsby, E. F. Pevere, L. A. Clarke, and G. B. Hatch to The Texas Company.

A solution of olefin in sulfuric acid is subjected to contact with substantially olefin-free low-boiling isoparaffin to strip absorbed olefin product from the acid. The resulting mixture is passed to a reaction zone containing an alkylation catalyst maintained under alkylating conditions such that the isoparaffin is alkylated by the olefin product with the formation of saturated hydrocarbons boiling within the gasoline range.

U.S.P. 2,348,637. Alkylation with Olefin Mixtures. R. N. Meinert to Standard Oil Development Company.

Isoparaffins are alkylated with a mixture of ethylene and at least one other monolefin, the olefins having a molar ratio of between 3:1 and 1:2. The alkylation reaction takes place at 35-80°F. in the presence of a substantially saturated aqueous solution of boron trifluoride. The isoparaffin must be in substantial molar excess over the olefin, and the hydrocarbon-to-catalyst volume ratio in the reactor is maintained at 2:1.

U.S.P. 2,349,211. Alkylation Process. A. J. Tulleners to Shell Development Company.

An alkylation process is described in which isoparaffins are alkylated with olefin polymers.

U.S.P. 2,349,458. Reaction of Paraffinic Hydrocarbons. J. J. Owen and E. E. Stahly to Standard Oil Development Company.

Isobutane is reacted with a relatively high-molecular-weight acyclic paraffin in the presence of an alkylation catalyst such as a metal halide-aluminum halide double-salt complex, to form saturated liquid hydrocarbons boiling in the gasoline range. NaCl-$AlCl_3$ double salts supported on celite and having a molar ratio of $AlCl_3$:NaCl of between 1.1 and 2.0:1 are suitable catalysts at 300-500°F. and 1000-3000 pounds pressure.

U.S.P. 2,350,501. Process for Producing Hydrocarbons. F. E. Frey and H. J. Hepp to Phillips Petroleum Company.

In the alkylation process described, paraffins are maintained at a pressure in excess of 1000 pounds and at a temperature of between 750-100°F. for a period such that decomposition of paraffins does not exceed 10 percent. The olefins are added during this period in at least two portions each of which comprises a different olefin and in such a manner that the concentration of unreacted olefin does not exceed 10 percent.

U.S.P. 2,351,464. Alkylation of Isoparaffins. A. Voorhies and E. M. Hattox to Standard Oil Devolopment Company.

Ethylene and isoparaffin are contacted with an acid of the class consisting of sulfuric acid and fluorosulfonic acid under alkylation conditions. The acid is separated from the reaction product and used in a second reaction zone with isoparaffins and olefins free of ethylene.

U.S.P. 2,351,609. Alkylation of Hydrocarbons. V. Haensel to Universal Oil Products Company.

A mixture rich in isoparaffins and olefins is prepared from a hydrocarbon fraction containing isoparaffins, normal paraffins and olefins by extracting olefins with an aqueous selective solvent. The paraffins are fractionated and the olefins extract stripped of olefin by contact with the i-paraffinic portion from the fractionator. Methyl ethyl ketone is a suitable solvent.

U.S.P. 2,353,766. Treatment of Hydrocarbons. L. Schmerling to Universal Oil Products Company.

An i-paraffinic hydrocarbon is reacted with a halo-olefin in the presence of a metal-halide catalyst of the Friedel-Crafts type at a temperature of from about —30 to about 100°C. Sufficient pressure is applied to keep a substantial portion of the reaction mixture in liquid phase.

U.S.P. 2,354,595. Two-Stage Alkylation Process. B. Hopper to Union Oil Company of California.

A series of olefins, preferably with 3 or 4 C atoms per mol, mixed with an isoparaffin, such as isobutane is contacted with sulfuric acid having a sulfuric-acid concentration between 92-100 percent and preferably of 96 percent at temperature at which one of the olefins reacts with the isoparaffin to form an alkyl hydrocarbon and at which temperature another olefin of the series does not react to any appreciable extent with the isoparaffin but simply passes into solution in the sulfuric acid. The acid containing the dissolved olefin is recovered and the temperature increased to a point at which the olefin will react with isoparaffin, when contact with the isoparaffin is established.

U.S.P. 2,354,641. Treatment of Paraffin Hydrocarbons. C. G. Gerhold to Universal Oil Products Company.

The invention comprises catalytically interacting i-butane and n-butenes in the presence of concentrated sulfuric acid using a large excess of isobutane to butenes, continuously removing a portion of the acid-hydrocarbon mixture, separating the acid and hydrocarbons, directing the latter to a separate zone for separation into i-butane, n-butene, alkymer of the motor fuel range and heavier products, reacting the used acid with i-butane in a separate reaction and returning the mixture of i-butane and regenerated acid to the alkylation zone.

U.S.P. 2,354,851. Process for Effecting Hydrocarbon Conversion Reactions. J. D. Danforth to Universal Oil Products Company.

A process for effecting hydrocarbon conversion reaction to produce branched-chain saturated hydrocarbons in the presence of a catalyst which comprises passing a stream of a substantially satu-

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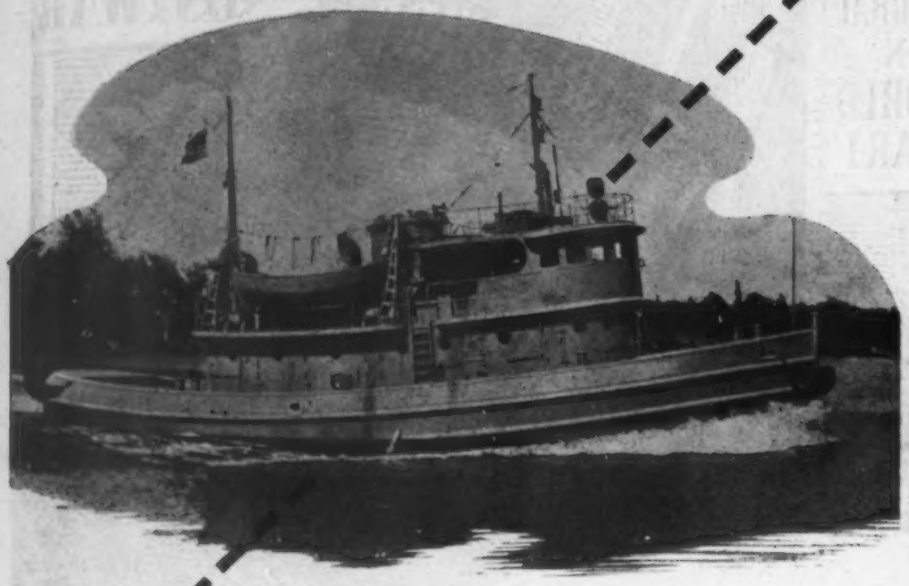

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rated hydrocarbon through a first contact zone containing a Friedel-Crafts type catalyst to form a substantial yield of alkylatable saturated hydrocarbons, causing the resultant hydrocarbon mixture comprising alkylatable saturated hydrocarbons to remove a portion of said catalyst from said first zone, maintaining a higher catalyst concentration in said first zone than in the effluent therefrom, permitting substantially the whole of the resultant effluent from the said first zone to flow into a second contact zone containing a solid packing material in the form of granular particles, and introducing to at least one point intermediate the inlet and the outlet of said second zone from an outside source an olefin-containing hydrocarbon fraction to effect formation on branched-chain saturated hydrocarbons by reaction of said alkylatable saturated hydrocarbons with olefins in the presence of the Friedel-Crafts catalyst and packing material in said second zone.

U.S.P. 2,355,339. Manufacture of Motor Fuels. L. G. Story to The Texas Company.

Reactions involving alkylation are advantageously carried out in the presence of hydrogen or a hydrogen-producing material or a hydrogen-containing gas. Hydrogen pressures of 50-1000 psi are preferably used. The hydrogen functions primarily to control the course of reaction and increase the life of the catalyst. Combined alkylation and hydrogenation catalysts are preferably used.

U.S.P. 2,355,460. Two-Stage Alkylation Process. C. E. Morrell to Standard Oil Development Company.

In a two-stage alkylation process involving the extraction of olefins with concentrated sulfuric acid followed by contacting the resulting olefin extract with at least one i-paraffin containing at least one tertiary C atom/mol under alkylating conditions, the improvement is claimed, which comprises extracting the olefins with a concentrated sulfuric acid-olefin extract for a time only sufficient to produce an olefin extract containing between about 0.4-1.3 mols of olefin per mol of acid.

U.S.P. 2,356,001. Conversion of Hydrocarbons. H. Pines and V. N. Ipatieff to Universal Oil Products Company.

Alkylcyclopentane hydrocarbons are reacted with olefins in the presence of an acid of phosphorous to produce alkylcyclohexanes. Temperatures between 100-400°C. are employed.

U.S.P. 2,356,374. Alkylation. A. L. Blount to Union Oil Company of California.

A mixture of olefins is subjected to a polymerization process wherein at least one of the olefin members is converted to polymer and the other remains unchanged. The polymer and the unpolymerized olefin are separated and separately mixed with an i-paraffin and contacted with an alkylation catalyst such as sulfuric acid. Higher yields are obtained than by alkylating mixed olefins.

U.S.P. 2,357,607. Multiple-Stage Catalytic-Alkylation Process. C. L. Ocon and E. A. Ocon.

Olefins and i-paraffins are alkylated in a ratio of 1:2 to 1:10 with sulfuric acid at —10 to 20°F. The products and

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the acid are separated, the products passed to a second zone where they are contacted with additional acid at 20-70°F. in the presence of additional pentenes and hexenes, so that an i-paraffin : olefin ratio of 7:1 to 10:1 prevails.

U.S.P. 2,359,119. Alkylation Process. H. M. Karr and C. McHenry to Shell Development Company.

An alkylation process consisting of feeding i-butane and butylene in liquid phase into an emulsion of concentrated sulfuric acid and hydrocarbon is described which is characterized by maintaining the volume ratio of acid to hydrocarbon in the emulsion between 0.9:1 and 1.5:1 and the viscosity between 0.65-0.95 poise at 5-15°C.

U.S.P. 2,359,542. Catalytic Alkylation of Isoparaffins. W. E. Bradley and K. J. Korpi to Union Oil Company of California.

An alkylation catalyst consisting of a mixture of concentrated sulfuric acid and an oxide of phosphorus is employed. A mixture of 10 percent by volume of 85 percent orthophosphoric acid and of 90 percent of 98 percent sulfuric acid is suitable. Reaction temperatures of 75°F. and pressures of 40-70 psi are used.

U.S.P. 2,360,358. Manufacture of Ethylbenzene. W. J. Mattox to Universal Oil Products Company.

Ethylene is alkylated with benzene. Monoethylbenzene is separated and polyethylbenzene is subjected to a dealkylation treatment to produce monoethylbenzene which is separated and recovered. A portion of the liquid hydrocarbons boiling below monoethylbenzene is returned to the dealkylation step and another portion together with ethylene to the alkylation step. Friedel-Crafts catalysts are used for alkylation, silica-alumina catalysts for dealkylation.

U.S.P. 2,360,436. Hydrofluoric-Acid Alkylation of Paraffins. M. P. Matuszak to Phillips Petroleum Company.

An alkylation vessel is described, consisting of an alloy containing 50-80 percent by weight of nickel, the balance being chiefly iron.

U.S.P. 2,360,547. Alkylation Process. J. A. Chenicek to Universal Oil Products Company.

I-butane is reacted with ethylene in the presence of $AlCl_3$ and HCl. A n-butane-ethyl chloride azeotrope is separated from the reaction products and contacted with benzene under alkylation conditions. HCl from the reaction of ethyl chloride with benzene is recycled to the first zone.

U.S.P. 2,361,065. Alkylation of Aromatic Hydrocarbons. L. Schmerling and V. N. Ipatieff to Universal Oil Products Company.

Aromatic and naphthenic hydrocarbons are alkylated at 200-450°C. and 1-200 atm. pressure in the presence of a catalyst comprising zinc chloride, zinc oxychloride and zinc hydroxychloride.

U.S.P. 2,361,355. Alkylation Process. A. N. Sachanen and S. B. Davis to Socony-Vacuum Oil Company.

Aromatic hydrocarbons or other aromatic compounds are alkylated at elevated temperature and pressure in the presence of a catalyst consisting of an organic halide such as a chlorine deriva-

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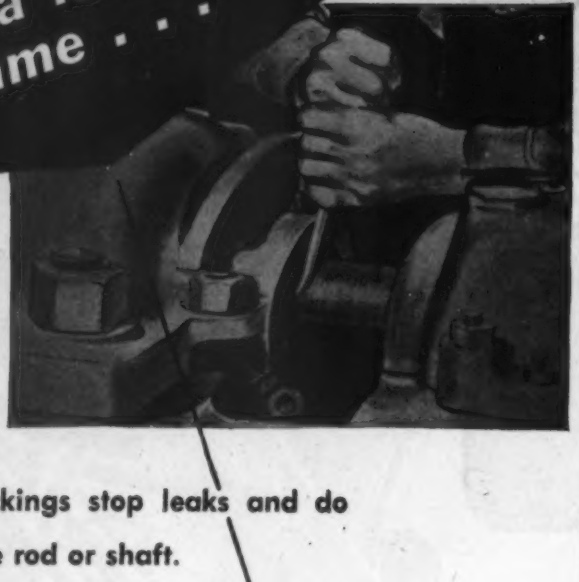

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tive of a light paraffin hydrocarbon. Temperatures of 500-700°F. and pressures above 200 psi are employed.

U.S.P. 2,361,365. Alkylation Process. A. N. Sachanen, A. A. O'Kelly and R. H. Work to Socony-Vacuum Oil Company.

Paraffin hydrocarbons (either n-or i-paraffins) are alkylated with olefinic hydrocarbons at 500-800°F. and at about 500 psi in the presence of a catalyst consisting essentially of an organic halide and any non-volatile metal which is capable of reacting with HCl under the conditions of the process. Aluminum and iron are preferred.

U.S.P. 2,361,465. Chemical Process. B. M. Filbert to Standard Oil Development Company.

A two-stage alkylation process is described. Olefins are charged to an absorption zone where they are substantially completely reacted with sulfuric acid. Monoalkylsulfates are withdrawn as bottoms and contacted in a second step with isoparaffins. The dialkylsulfates are returned to the absorption zone to suppress further formation of the same.

U.S.P. 2,361,600. Conversion of Hydrocarbons. D. R. Carmody to Standard Oil Company (Indiana).

In a process of producing a saturated hydrocarbon from i-paraffinic and olefinic hydrocarbons, the steps are claimed consisting of absorbing olefin-containing gases in dilute sulfuric acid, diluting the acid further to separate out the alcohols, contacting the resulting alcohols with isoparaffinic hydrocarbons in the presence of concentrated sulfuric acid at a temperature at which a higher-molecular-weight saturated hydrocarbon and water are produced, thereby diluting the sulfuric acid and supplying the diluted sulfuric acid to the first-mentioned absorption step.

U.S.P. 2,363,116. Alkylation of Hydrocarbons. F. H. Bruner to The Texas Company.

A catalyst consisting of boron trifluoride, water and hydrogen fluoride and which does not require the presence of metallic substances is employed for alkylation reactions. The catalyst is prepared by saturating an aqueous hydrogen fluoride solution with boron trifluoride at room temperature.

U.S.P. 2,363,222. Catalytic Alkylation. F. J. Beyerstedt to Standard Oil Development Company.

An alkylation catalyst composition is prepared by bubbling boron trifluoride into an aqueous phosphoric acid solution of between 85 and 100 percent concentration. The alkylation reaction is carried out at 40-70°F. and under sufficient pressure to insure liquid-phase operation.

U.S.P. 2,363,300. Production of Motor Fuel. A. E. Dunstan and S. F. Birch to Anglo-Iranian Oil Company.

Isomeric butylenes are polymerized to dibutylenes and then reacted with isobutane to form isooctane.

U.S.Pl 2,363,301. Production of Motor Fuel. A. E. Dunstan and S. F. Birch to Anglo-Iranian Oil Company.

The alkylation of isoparaffins and olefins is carried out at a temperature between —10 and + 20°C. in the presence of concentrated sulfuric acid while corre-

lating the reaction conditions to produce a normally liquid, substantially completely saturated product, the volumetric ratio of the total hydrocarbon present in the reaction zone to the amount of sulfuric acid present therein being maintained between about 1.5:1 and 4.4:1.

U.S.P. 2,364,203. Alkylation. A. W. Francis and E. E. Reid to Socony-Vacuum Oil Company.

Aromatic compounds are alkylated by passing them with alkyl halides and olefins through a liquid catalyst mass, consisting of a complex of aluminum chloride and alkylate. The catalyst is maintained at a temperature between the boiling point of the desired alkylate and the boiling point of the next higher alkylate, retaining the major portion of higher-boiling material in the catalyst complex.

U.S.P. 2,364,430. Alkylation Process Employing Hydrogen. C. Ellis to Standard Oil Development Company.

A paraffinic hydrocarbon and a monolefinic hydrocarbon, the former being in substantial molar excess over the latter are admixed with hydrogen (in a concentration lower than that of either hydrocarbon) and subjected to the action of a solid dehydrogenation catalyst at 200-500°C. and under elevated pressure. Tungsten and molybdenum oxides or sulfides are suitable catalysts.

U.S.P. 2,364,451. Chemical Process. H. F. Kohler to Standard Oil Development Company.

Olefins are contacted with concentrated sulfuric acid in a ratio of 25-200 mols of acid per mol of olefin at 0-75°F. to prepare monoalkyl sulfates suitable for subsequent alkylation with isoparaffins.

U.S.P. 2,364,762. Treatment of Aromatic Hydrocarbons. L. Schmerling and A. M. Durinski to Universal Oil Products Company.

Alkylated aromatic hydrocarbons are produced by contacting an aromatic hydrocarbon with an alkyl halide in the presence of a metal oxide catalyst. Temperatures of 100-500°C. and pressures up to 200 atm. are used in the presence of hydrogen. Suitable catalysts are zinc oxide, ferric oxide, magnesium oxide, alumina, bauxite, silica gel, diatomaceous earth, clays, silica composites, etc.

U.S.P. 2,365,860. Alkylation of Isoparaffinic Hydrocarbons. W. E. Bradley and K. J. Korpi to Union Oil Company of California.

Alkylation of isoparaffinic and olefinic hydrocarbons is carried out in the presence of a catalyst consisting of solid acid sulfates and mixtures of solid acid sulfates with acid phosphates. Temperatures below 750°F. and pressures from 20 to 300 psi are employed.

U.S.P. 2,366,627. Manufacture of Antiknock Hydrocarbons. L. C. Kemp to The Texas Company.

Olefins and paraffins are alkylated with sulfuric acid in a plurality of reaction zones which are maintained at various temperatures.

U.S.P. 2,366,731. Alkylation of Isoparaffins. V. N. Ipatieff and C. B. Linn to Universal Oil Products Company.

The alkylation reaction is carried out in the presence of boron trifluoride and fluoro-sulfonic acid. Temperatures from

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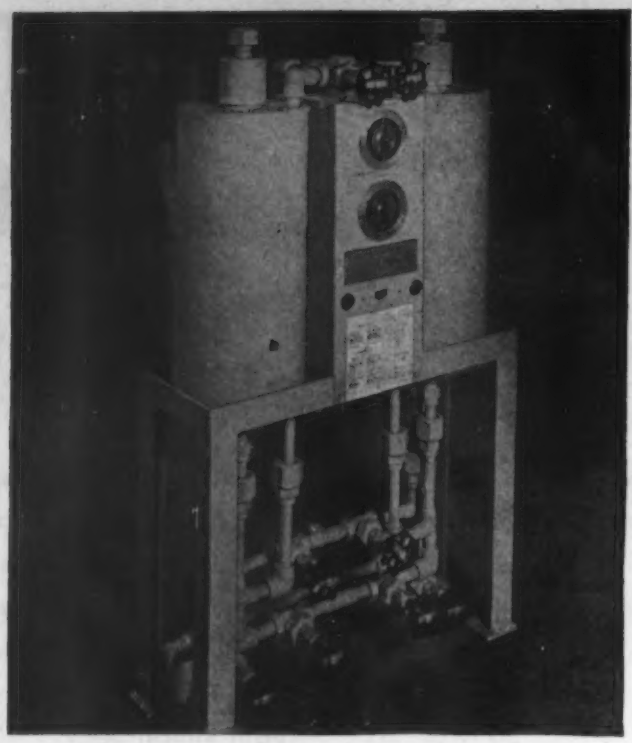

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0-100°C. and sufficient pressure to maintain liquid phase are employed.

U.S.P. 2,366,736. Alkylation of Isoparaffins. C. B. Linn and V. N. Ipatieff to Universal Oil Products Company.

A catalyst consisting of boron trifluoride and an acid fluoride such as potassium acid fluoride is used. Reaction temperatures range from 10-50°C.

U.S.P. 2,368,063. Reaction of Hydrocarbons. L. P. Elliott to Standard Oil Company of California.

Heavy alkylmers produced by alkylation with either sulfuric-acid type catalysts or Friedel-Crafts type catalysts when treated with an alkylation catalyst under appropriate conditions in a secondary zone are converted in substantial part to more volatile products entirely analogous to the light alkylmers produced in the main reaction.

U.S.P. 2,370,030. Conversion of Hydrocarbons. A. R. Goldsby to The Texas Company.

A combination alkylation and dehydrogenation process is described. Unreacted n-paraffins from the alkylation reaction are dehydrogenated and returned to the alkylation step as olefins.

U.S.P. 2,370,164. Alkylation Process. L. M. Hemphill to Shell Development Company.

I-paraffins and naphthenes having a tertiary C atom are alkylated in a plurality of reaction stages to each of which is fed the hydrocarbon to be alkylated and an alkylating agent. In each stage the reactions are emulsified with a liquid alkylation catalyst using a large excess of hydrocarbon to be alkylated over alkylation agent. Reacted emulsions are withdrawn to a separator. Fresh catalyst is fed to one reaction stage only, the catalyst for succeeding stages being supplied in the form of emulsified reaction mixture.

U.S.P. 2,370,771. Alkylation. E. W. Bowerman to Standard Oil Development Company.

In a two-stage alkylation process comprising an absorption zone where a mixed feed stock containing olefins and paraffins is contacted with sulfuric acid to form an extract phase and a raffinate phase, and a first alkylation zone, wherein the said extract is reacted with i-paraffin under alkylation conditions in the presence of sulfuric-acid catalyst, the improvement is claimed which comprises withdrawing raffinate from the absorption zone and passing it to a second alkylation zone, withdrawing from the first alkylation zone the fluid which has taken part in the alkylation reaction and passing it to the second alkylation zone and reacting it with the raffinate under alkylation conditions.

U.S.P 2,371,408. Refining Mineral Oil. P. T. Parker to Standard Oil Development Company.

Tertiary hydrocarbons are alkylated by passing a feed stream containing olefins to an initial stage, absorbing the olefins with a mineral acid under conditions whereby the mineral acid is the discontinuous phase and in which the ratio of acid to olefin is between 10 and 100:1, withdrawing the acid solution and contacting the same in a second stage with added i-paraffinic hydrocarbons in

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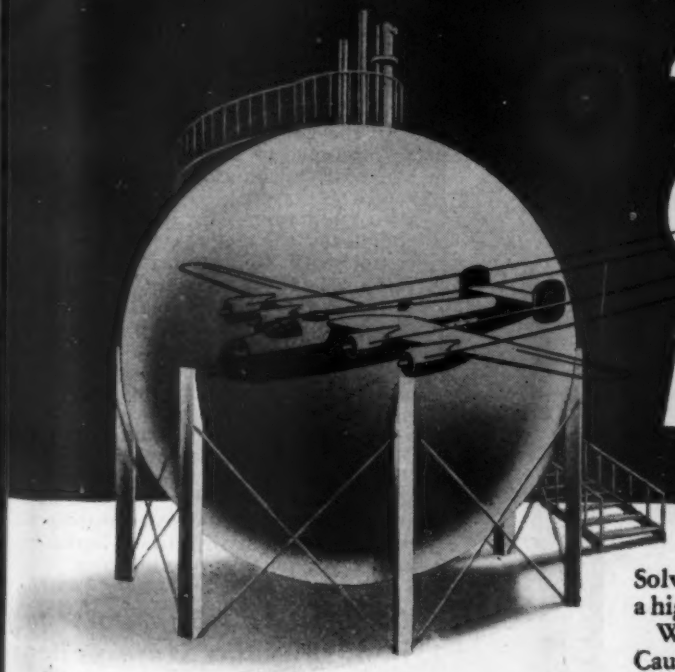

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the presence of an alkylation catalyst under alkylating conditions.

U.S.P. 2,372,505. Alkylation of Aromatic Hydrocarbons. C. B. Linn to Universal Oil Products Company.

Olefins are reacted with hydrogen fluoride at low temperatures to form alkyl fluorides. These are separated from such paraffins as may be present at low temperatures and under pressure higher than the vapor pressure of all components. An excess of HF is used. Aromatics are then alkylated with the solution of alkyl fluorides in HF at —10 to 150° C. under sufficient pressure to maintain liquid phase.

U.S.P. 2,372,320. Hydrocarbon Alkylation Process. F. E. Frey to Phillips Petroleum Company.

Ethylbenzene is produced from benzene and an olefin fraction containing ethylene in a two-step alkylation process, using HF as a catalyst. In the first step, the higher olefins are alkylated with i-paraffins, while ethylene is converted to ethyl fluoride; in the second step, the ethyl fluoride is reacted with benzene.

U.S.P. 2,372,338. HF Alkylation Process. J. R. Penisten to Universal Oil Products Company.

In the conversion of hydrocarbons in the presence of HF catalyst where in a hydrocarbon mixture containing dissolved HF is separated from used catalyst containing hydrocarbon-fluorine complexes, the method is claimed, which comprises heating at least a portion of said used HF catalyst sufficiently to decompose and release HF from said complexes, introducing the thus treated used catalyst and said hydrocarbon mixture into a fractionating zone, vaporizing HF and hydrocarbon from the commingled materials in said zone while refluxing components of said mixture to separate HF as a vapor from higher-boiling hydrocarbons in the form of liquid, removing HF-containing vapor from the upper portion of the fractionating zone and removing hydrocarbon liquid from the lower portion of said zone.

Dr. Maxwell Gensamer to Pennsylvania State College

Dr. Maxwell Gensamer, a staff member at Carnegie Institute of Technology for 16 years, has become professor of metallurgy and head of mineral technology at Pennsylvania State College. Dr. Gensamer's professional association with Carnegie Tech began in 1929 when he was a graduate student and research assistant in the metals research laboratory. He began teaching metallurgy in 1935 and, since 1943, has held the rank of full professor.

Gas for Carbon Black

Charles Eneu Johnson & Company has been authorized by the Oklahoma Corporation Commission to purchase residue gas from Warren Petroleum Corporation's gasoline plant near Madill, Oklahoma, for manufacture of carbon black at its plant near Stonewall, Oklahoma. The price was fixed at five cents per thousand cubic feet. The company is manufacturing black through the channel process and disposing its entire output to the government to meet wartime demands.

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(2) Selected materials for resistance to corrosion, erosion and galling.

(3) Skirt guided — top and bottom guided (both V-port and formed plunger) — conventional throttling or percentage type characteristics.

(4) Stems reversible in field.

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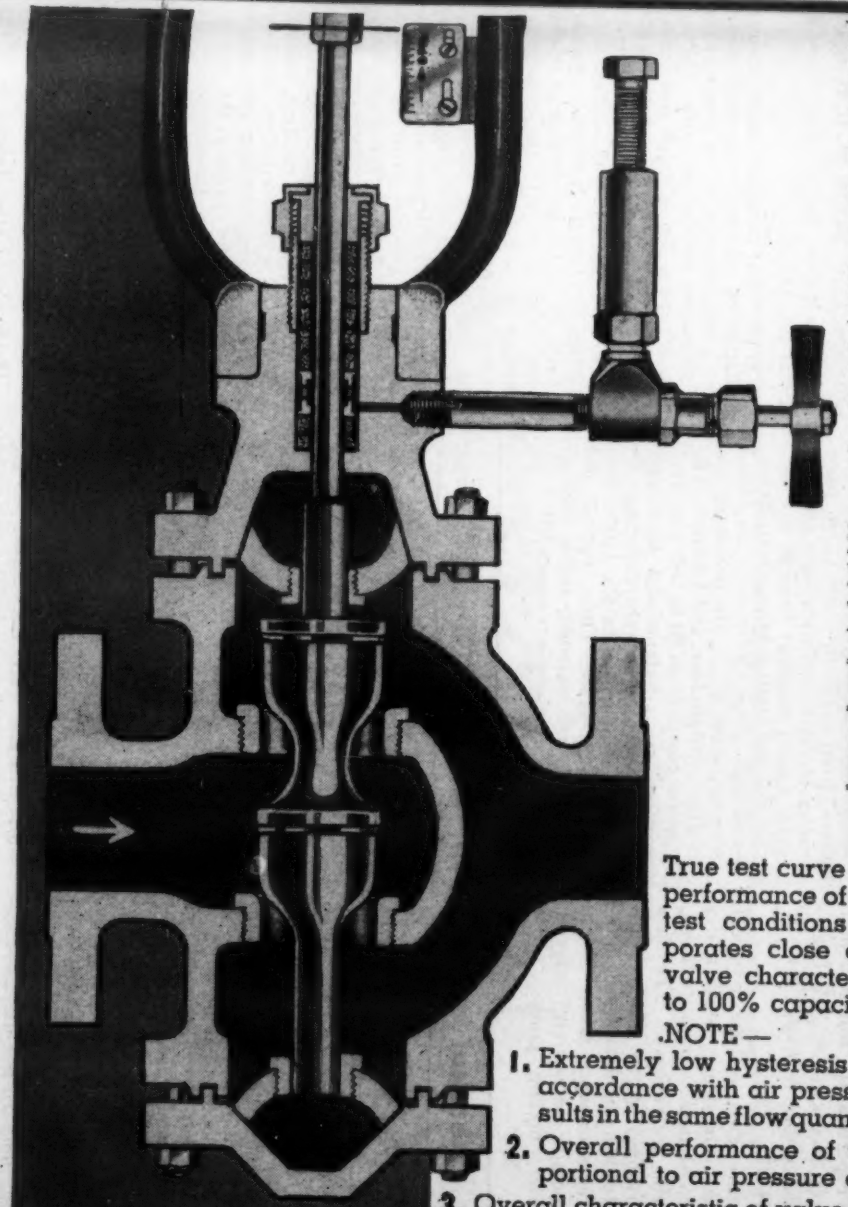
(1) Large flow passages to minimize flow friction losses.

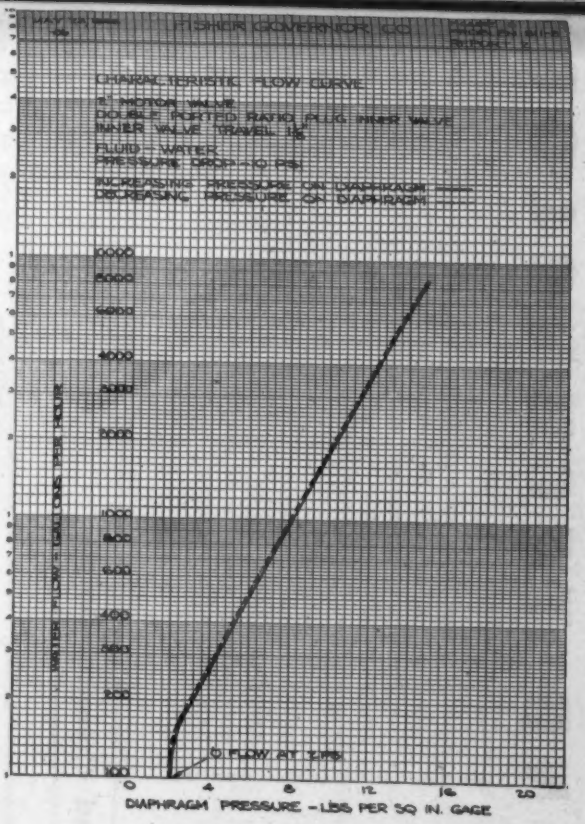
(2) Full size port openings capable of developing full line area.

(3) Distance between ports designed to avoid inner valve interference to flow.

(4) Wall section built to ASA fittings standard — iron bodies 250 lbs. — steel bodies 600 lbs. regardless of end fittings.

(5) Deep packing stuffing box designed for molded packing to minimize leakage — lubricated to minimize friction.





True test curve from our engineering files, illustrating actual performance of diaphragm motor valve illustrated and under test conditions specified. Inner valve construction incorporates close clearances — clearance flow is 1.9%. Flow valve characteristic is of percentage flow type from 1.9% to 100% capacity.

NOTE —

1. Extremely low hysteresis — accurate positioning of the inner valve in accordance with air pressure changes on the diaphragm — always results in the same flow quantity for any given specific air loading pressure.
2. Overall performance of the valve is uniform with and directly proportional to air pressure change on the diaphragm.
3. Overall characteristic of valve gives proper performance over wide changes of flow — permits handling wide range of pressure drop and flow conditions.

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Traver Road, Ann Arbor, Michigan
under supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by The Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical and Chemical Data

Physical Properties of Butanes and Butenes. R. C. WACKHER, C. B. LINN, AND A. V. GROSSE. *Ind. & Eng. Chem.* **37** (1945) pp. 464-68.

The literature data on the physical properties of n-butylene, isobutane, 1-butene, cis-2-butene, trans-2-butene, and isobutylene are reviewed. The data were redetermined when discrepancis appared, and when no data were available, measurements were taken. These properties include refractive indices, liquid densities, boiling points, vapor pressures, and melting points. Refractive indices, from —10° to —50° C. on pure samples of the C_4 hydrocarbons are presented. Liquid densities from 0° to —70° C. for cis- and trans-2-butene were determined and given. New data on liquid densities below 0° C. are presented for isobutane, isobutylene, and 1-butene. The vapor pressures from 20 to 800 mm. were measured on n-butane and isobutane, and are presented as substantiating evidence in comparison to the latest data from the literature. Three figures and nine tables are included, and a bibliography of 27 references is appended.

Chemical Compositions and Reactions

The Chemistry of Dicyclopentadiene. I. Hydration and Rearrangement. H. A. BRUSON AND T. W. RIENER. *Jour. Amer. Soc.* **67** (1945) pp. 723-28.

The hydration of dicyclopentadiene and tricyclopentadiene by means of aqueous sulfuric acid yields unsaturated, secondary monohydric alcohols having a different ring system than the original dienes. This result is caused by a molecular rearrangement in the terminal bridged cyclohexene ring. The hydration-rearrangement of dicyclopentadiene yields hydroxy-dihydro-nor-dicyclopentadiene and the ether thereof. The latter is obtainable by the reaction of dicyclopentadiene with hydroxy-dihydro-nor-dicyclopentadiene in the presence of acidic condensing agents. Hydroxy-dihydro-nor-dicyclopentadiene has been converted into its corresponding unsaturated ketone, saturated alcohol, saturated ketone, unsaturated chloride and parent saturated and unsaturated hydrocarbons.

Allylic Rearrangements. XVIII. Coupling Reactions of Butenylmagnesium Bromide. W. G. YOUNG, J. D. ROBERTS AND H. WAX. *Jour. Amer. Chem. Soc.* **67** (1945) pp. 841-3.

Butenylmagnesium bromide couples with allylic bromides to give mixtures of diolefins, whereas with allylic chlorides it yields individual products predominately. The principal products of the coupling reaction of allylic chlorides with butenylmagnesium bromide may be considered to be derived from the secondary form of the Grignard reagent. The reaction of butenylmagnesium bromide with n-butyl chloromethyl ether gives s-butenylcarbinyl n-butyl ether.

Simultaneous Polymerization and Degradation in Polymer Systems: Styrene in Toluene Solution. R. MESROBIAN AND A. TOBOLSKY. *Jour. Amer. Chem. Soc.* **67** (1945) pp. 785-7.

The authors studied the polymerization of styrene and the depolymerization of styrene polymers, both in toluene solution. To demonstrate the simultaneous occurrence of polymerization and depolymerization, monostyrene and various polystyrene solutions of the same weight concentration were maintained at elevated temperatures under the same conditions of temperature and catalytic environment. The viscosities of these solutions were measured at suitable intervals during the course of the experiments. Sealed viscometers were used that were reversible. These were placed on an asbestos board five inches beneath a G. E. No. 1 Sunlamp mounted with a standard reflector. The steady state temperature attained at the level of the viscometer bulbs was 100° C. Under the combined influence of light, heat and possibly the oxygen sealed into the viscometers, the viscosity of the styrene solutions changed. This change was followed periodically, measuring the time of flow of the solutions through the capillary of the reversible viscometer, which during measurement of viscosity was kept in a constant temperature of 25° C. It was found that after about 350 hours a steady state was reached and the viscosity of all the solutions stops changing. A steady state, or what may be a true equilibrium state, was reached.

Catalytic Vapor-Phase Oxidation of Ethylene. E. T. MCBEE, H. B. HASS, AND P. A. WISEMAN. *Ind. & Eng. Chem.* **37** (1945) pp. 432-38.

A study of the catalytic, vapor-phase air oxidation of ethylene was made using a silver catalyst prepared by coating pieces of corundum with silver oxide. The temperature range investigated was between 225° and 325° C. The products isolated were ethylene oxide, carbon dioxide, and water. The catalyst was studied to determine the most favorable operating conditions for the production of ethylene oxide. It was found that a large air-ethylene ratio is most suitable for obtaining both good yields and conversions. The temperature of optimum yields is somewhat lower than that of optimum conversion. The temperature of operation of the catalyst must be raised as the contact time becomes shorter to maintain maximum efficiency; small additions of ethylene dichloride to the reactants are desirable, large additions are harmful; such a catalyst, when deactivated by excess ethylene dichloride, can be revived by raising the operating temperature and passing the reactants over the catalyst simultaneously. The apparatus and its operations are described, as well as the preparation of the catalyst. As the catalyst ages it becomes less and less efficient for the production of ethylene oxide, and as a consequence the temperature of operation must be raised.

Oxidation of Hexadecane. H. B. HASS, E. T. MCBEE, AND J. W. CHURCHILL. *Ind. & Eng. Chem.* **37** (1945) pp. 445-48.

Alcohols possessing long aliphatic chains are commercially important in the production of detergents, synthetic waxes, insecticides, fungicides, and wetting, emulsifying, and foam-producing agents. Such alcohols are obtained industrially by the catalytic hydrogenation of esters of the corresponding acids. The availability and low cost of raw materials has stimulated interest in the production of these higher alcohols by air oxidation of hydrocarbons. Aliphatic hydrocarbons are easily oxidized. Bubbling air through hexadecane at 110° C. and atmospheric pressure will effect dehydrogenation, carbon-carbon fusion, and the formation of alcohols, aldehydes, acids, ketones, peroxides, carbon dioxide, and water. Ease of oxidation increases with

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molecular weight in any homologous series. The authors' investigation was concerned with the preparation of higher alcohols from hexadecane by oxidation in the liquid phase with air and subsequent hydrogenation. Hydrocarbon-air mixtures under a pressure of 2000 pounds per square inch passed through a glass-lined reaction tube, immersed in a salt bath; the reaction products were quickly cooled and were dried over anhydrous calcium sulfate and then analyzed. The apparatus and procedure are described in some detail. The products were analyzed for alcohols, acids, esters, and carbonyl compounds. Hydrogenation of the oxidation products gave materials containing alcohols having average molecular weights as high as 165. Conversions for the two-step process were as high as 17 percent. Oxidations at 300° C. were characterized by the formation of sooty suspensions and products low in partial oxidation products.

Oxidation of Chlorinated Hydrocarbons to Maleic and Fumaric Acids. W. L. FAITH. *Ind. & Eng. Chem.* **37** (1945) pp. 438-41.

In certain instances polychlorinated aliphatic hydrocarbons are industrial by-products of comparatively low value. Accordingly such polychlorides may be available as cheap raw materials for chemical processes. The author describes a process by means of which chlorinated hydrocarbons can be converted to more valuable products, such as maleic or fumaric acids, by simultaneous catalytic vapor-phase oxidation and dehydrochlorination. Hydrochloric acid is a by-product of the reaction. Vanadium pentoxide catalyst was used. Data are presented for the oxidation of n-butyl chloride, n-butyl bromide, 1,2-dichlorobutane, mixed amyl chlorides, dichloropentane, polychloropentanes, n-hexyl chloride, and keryl chloride. The effect of temperature, space velocity, molar air-halide ratio, carrier, diluents, and pressure on the dichloropentane oxidation was determined. Optimum conversions, using vanadium pentoxide on Alfrax at 425-450° C. at a space velocity of 50 reciprocal hours, were 0.35 mole fumaric acid and 1.88 moles hydrochloric acid per mole of commercial dichloropentanes. Whether maleic or fumaric acid was obtained depended upon the concentration of hydrochloric acid in the recovery system. The process appears to be a suitable means of utilizing the by-product polychlorinated hydrocarbons.

Petroleum at War. W. S. MORRIS. *Min. & Met.* **26** (1945) p. 105.

Of the total tonnage of overseas shipments for war purposes, 65 percent is petroleum products. One thousand one hundred gallons of high-octane gasoline are required for a bomber to fly from London to Berlin and return. A 1000-plane raid requires over a million gallons of gasoline. The Navy's need for diesel oil in 1944 was 2100 percent of its 1941 needs. Fuel oil requirements are 500 percent of the 1941 consumption. Practically all oil fields in the United States must produce at their maximum efficient rates in order to produce the crude oil required. In late 1944 the daily volume of crude oil run to stills reached approximately 4.75 million barrels.

Manufacture: Processes and Plant

The Synthesis of Methane. J. G. KING. *Gas World* **122** (1945) pp. 196-200.

Methane synthesis can be used industrially for producing gas of high calorific value, for enriching and detoxifying coal gas, for making gas rich in methane which can be refrigerated to produce liquid methane for storage, as means of removal of CO from gas, and as a means of stabilizing the combustion characteristics of city gas. With a high ratio of hydrogen to carbon monoxide, the main reaction at low temperature and atmospheric pressure results in the formation of methane and water. However, some carbon dioxide and hydrogen result from the reaction of carbon monoxide and water. If the hydrogen-carbon monoxide ratio is lowered, the second reaction becomes more prominent and carbon dioxide appears in the final gas. When the ratio reaches unity methane and carbon dioxide are formed in equimolar proportions. Nickel catalysts have been prepared that operate at high space velocity and that have initial activity several times greater than is necessary to carry the reactions to equilibrium. The catalyst must be one of strong hydrogenating properties. The practical conditions that favor the operation of the catalytic reaction are: the exact maintenance of the temperature, pressure, and H_2/CO ratio, the control of the temperature of the reaction at the catalyst surface, and the prevention of reactions that liberate elementary carbon at the catalyst surface. Work on the control of these conditions and the results secured are described, but details will not be published until after the war.

Pilot Plant Development of Fluid Catalytic Cracking. L. E. CARLSMITH AND F. B. JOHNSON. *Ind. & Eng. Chem.* **37** (1945) pp. 451-55.

The Fluid Catalyst process has been developed from a laboratory scale to wide commercial use during the past several years. A total of 34 fluid catalyst cracking units have been built or are under construction. These plants are presently being used exclusively to produce aviation gasoline and raw materials for the war program. However, after the war they can be used to produce high-quality motor gasolines. The purpose of the present paper of the author is to trace the development of the fluid process through the laboratory, pilot plant, and semi-plant stages, and to describe the equipment used in the development. The design factors involved in the development of the process included such items as type of catalyst, feed stock, operating conditions, and yield and quality of product. Engineering and equipment studies included the mechanics of catalyst flow, catalyst recovery, methods of avoiding erosion, heat-transfer data, control and capacity of the regenerator and reactor, stripping of the spent catalyst, and the general knowledge required in any new process. After preliminary work

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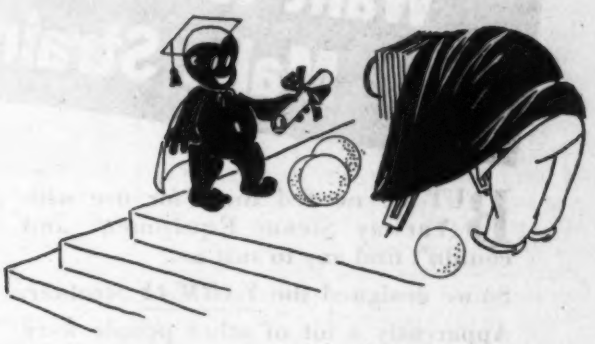

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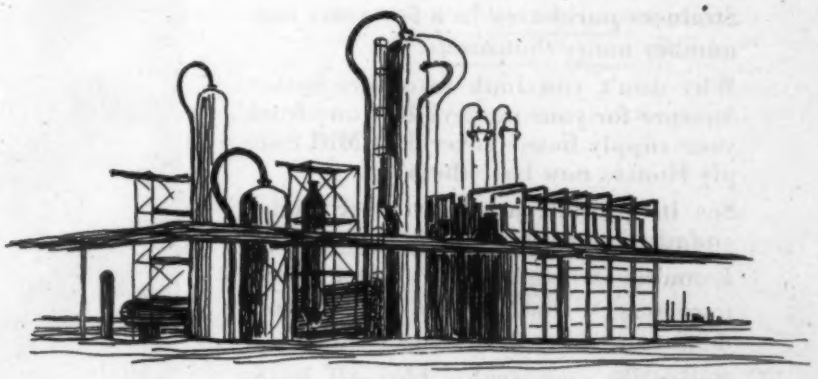

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a small pilot unit feeding approximately 2 barrels per day of gasoil was used to study feed stocks and catalysts. A larger unit of 100 barrels per day capacity was built to study engineering and equipment variables and to confirm process and catalyst data observed in the smaller unit. In addition to the pilot-plant unit numerous tests were made to study particular phases of the process. Flow-sheets of the several experimental plants are presented. Typical results in the experimental plant and in a commercial plant are given in tabular form.

The TCC Catalytic Cracking Process for Motor Gasoline Production. R. H. NEWTON. *Trans. Amer. Inst. Chem. Engrs.* 41 (1945) pp. 215-32.

The catalytic cracking of petroleum has been commercially practiced for eight years. Although the fundamentals of catalytic cracking are not extremely complex, the engineering details necessary to successful commercial operation of a plant have required a great amount of study. The TCC process is characterized by separation of the reaction and regeneration zones and continuous movement of a solid catalyst through each of these zones. The problems of uniform contact of the catalyst with the reacting vapors, isolation of the reaction and regeneration systems, maintenance of thermal balance by addition and removal of heat, and instrumentation and control for convenient and safe operation have been the subject of intense study. The factors governing rate of flow of pellet catalysts in beds, and methods of insuring uniform flow and distribution have been studied experimentally in plant-scale models. The characteristics of the cracking catalyst require a minimum temperature of about 900° F. to burn off the coke deposit, in order to regenerate the catalyst; and also dictate a maximum temperature of not over about 1200° F. in order to avoid damage to the catalyst. These requirements are satisfied by stepwise burning and cooling, and by limiting the temperature in any zone by control of the oxygen supplied. It is believed that the characteristic design of equipment and the application of simple engineering principles is not limited to the cracking of petroleum. Wherever a solid catalyst is contacted with vapor in a regenerative process, and the reaction pressures do not exceed 2 or 3 atmospheres, the TCC principle appears to be applicable. A general process flow diagram of the TCC plant, showing the essential units of the equipment required for feed preparation, catalytic cracking, regeneration and distillation of products is given. A typical heat balance is shown in tabular form. Diagrams are given showing mechanical details of various parts of the plant.

The Design and Operating Features of Houdry Fixed Bed Catalytic Cracking Units. R. H. NEWTON AND H. G. SHIMP. *Trans. Amer. Inst. Chem. Engrs.* 41 (1945) pp. 197-213.

The Houdry fixed-bed catalytic cracking process has a number of distinctive engineering features, to which the successful commercial functioning of this complex large-scale operation is in great measure due. The oil to be cracked and the air for regeneration of the catalyst are alternately passed through a bed

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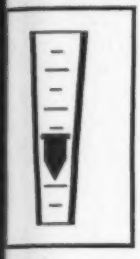
We make rotameters for flow rate measurement and control, and we believe it is important that you know about them because they offer advantages which you cannot obtain in any other flow rate measuring device. First, let us describe the principle of the rotameter.

The Principle of the Rotameter



The rotameter is an "area-type" meter in which the variation in area is obtained by means of a vertical *tapered* tube with the smallest diameter at the bottom. A weight of fixed diameter (called the "float") moves freely within this tapered tube and hence the area between the float and tube *increases* as the float rises. This area then becomes a measure of the flow and for every flow rate there is a fixed position of the float in the tube. Therefore, the rotameter can be accurately calibrated to read directly in flow rate. This method of flow measurement gives advantages of great importance.

The Advantages of the Rotameter

Succinctly stated, the main advantages of our rotameter are as follows:

(1) Since the metering tube is usually transparent, the main metering elements (float and tube) and the fluid being metered are ***clearly visible.*** High accuracy may be maintained because dirt accumulations are immediately perceived and because a secondary remote reading instrument, when used, may be quickly checked against the primary metering element, the rotameter.

(2) A wide flow range may be obtained in one rotameter. A ratio of 20 to 1 from maximum to minimum flow is easily reached if necessary.

(3) Since area variation is measured (rather than head), the calibration curve of the rotameter is practically a straight line so that a direct reading scale with evenly spaced divisions is obtained. There is no compression of the divisions at low flows, so the same high metering accuracy is gained ***throughout the flow range.***

(4) Because the area between the float and tube increases when the flow rises, the pressure drop across the float is low and ***constant.*** Pumping costs are reduced and low initial head may be tolerated by using an oversize meter with a light float.

(5) Our patented Stabl-Vis rotameter compensates for normal variations in viscosity and density so that viscous oils and chemicals, such as concentrated sulphuric acid, may be measured accurately in spite of wide temperature changes.

(6) The metering float travels a distance of at least 5 inches, and meters are obtainable with float travel as long as 24 inches. Hence, by shortening the flow range and lengthening the float travel, higher accuracies may be obtained with the rotameter than with any other flow rate measuring device.

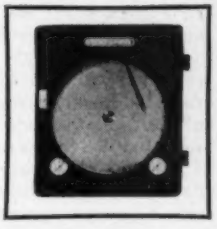
(7) The float moves freely in the metering tube so there is no friction or hysteresis. Therefore, the rotameter reaches the Instrument Engineer's ideal goal of high accuracy, ***consistently maintained*** during years of service.

(8) Due to its simplicity, the rotameter is readily made corrosion proof and, therefore, may be used to measure flows of gases, liquids and slurries that no other meter will handle with continuous success.

(9) Also, due to its simplicity, the rotameter is easy to install and reasonable to maintain.

The Scope of Fischer & Porter Rotameters

We originated the precision-bore tapered rotameter tube of boro-silicate glass, and have designed and built a full line of rotameters to solve the varied flow rate problems of Industry. We can measure liquid flows from 0.15 cubic centimeters per minute up to 14,000 gallons per minute, and gaseous flows from 3 cubic centimeters per minute up to 16,000 cubic feet per minute. Temperatures to 750° F. and pressures to 10,000 p.s.i. can be provided for in our equipment. Flow indication, flow recording, flow totalization and automatic flow control are all available to you in designs which have been proved by many field installations to be practical, accurate and dividend-paying meters.



A steady stream of basic improvements in the rotameter have come from our research laboratories. A most recent worthwhile development has been a marked betterment in the electrical inductance-bridge method of telemetering the position of the rotameter float to a remote recording or controlling instrument. This method in the past has been somewhat discredited by Instrument Engineers because it was subject to errors from temperature and voltage variations, and because it lacked power. Because of the great simplicity of the inductance-bridge principle, we decided not to accept this dictum, so we went to work to overcome its weaknesses. Today we can guarantee that our new circuit is not affected by wide variations in either temperature or voltage, and furthermore it has ***three times*** the power of any previous comparable instrument, so that the pen now positions with speed, positiveness and accuracy.

One of our most important new product announcements has been a Ratio Controller for controlling one or more flows at a fixed proportion of a main, varying flow. This controller is rapidly becoming a real factor in enabling many industries to carry on continuous reactions or percentage blendings with speed and accuracy.

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WELL WATER SYSTEMS
VERTICAL TURBINE PUMPS

of pelleted catalyst. The catalyst case is constructed to provide positive distribution of the vapors throughout the catalyst mass, and is equipped with finned heat-transfer elements for control of the temperature and removal of heat. The alternate oil and air cycles make it necessary to purge the catalyst before and after each operation. The purging is accomplished by evacuation. The cyclic operation is effected with three or more catalyst vessels so that the flow of both oil and air are continuous. The flow of vapors is controlled by specially constructed motor-operated valves that are governed by a 900-point automatic cycle timer. The heat control of the catalyst vessels is accomplished by circulating an inorganic salt heat-transfer medium. Because of the high heat-transfer coefficients obtained it is feasible to control the catalyst temperature within a maximum difference of about 200° F. of the salt temperature and to develop 450 pounds per square inch steam with excess heat. To promote rapidity of combustion of the carbon deposit, and permit maximum utilization of the catalyst, air at about 45 pounds per square inch pressure is used for regeneration. The hot fumes from the cases are expanded through a gas turbine which develops the power needed for compression as well as power to drive an electric generator. The cracking plant can be made substantially self-contained in its power and steam requirements. The precision of control of catalyst temperature, and the flexibility of the equipment, especially with respect to pressure and of operation is a noteworthy feature of the process and plant. Pressures of 5 inches of mercury absolute to over 200 pounds per square inch, gauge, pressure have been used in this type of equipment, and the wide choice of operating cycle permits almost any degree of severity of cracking that may be required. With present carbon-steel converters catalyst temperatures from about 650° to 875° F. are being used. Cycle-timer sequence is shown in tabular form. Typical heat and material balances are also presented in tabular form.

Hydrogen Sulfide Production from Sulfur and Hydrocarbons. R. F. BACON AND E. S. BOE. *Ind. & Eng. Chem.* **37** (1945) pp. 469-74.

Approximately 20,000 to 25,000 tons of hydrogen sulfide are now recovered or produced annually in this country. It is probable that the demand for this substance may increase. Hydrogen sulfide can be produced commercially from sulfur and various hydrocarbons. At temperatures of 250° C. heavy fuel oils will react with sulfur to give high yields of hydrogen sulfide. At 600-650° C. using various catalysts, sulfur will react quantitatively with methane and water vapor to form hydrogen sulfide and carbon dioxide. To prevent the formation of sulfur dioxide, the reaction can be carried out in two steps: (1) the reaction of sulfur with methane at 600-650° C. to form hydrogen sulfide and carbon disulfide, and (2) the conversion of the carbon disulfide at 300-350° C. to hydrogen sulfide and carbon dioxide by means of water vapor. The material cost per pound of hydrogen sulfide is approximately 1.1 cents. Although two reaction zones are required, the process is a con-

One of numerous gas processing plants designed and constructed by Petroleum Engineering, Inc. during its 16 years of service to the industry. *Petroleum Engineering, Inc. Offices: Tulsa and Houston.*

fing welding burrs
drum shell seam

ing heads to shell
of steel drum

STEEL DRUMS FOR WAR WILL SERVE PEACE, TOO

The conversion of steel sheets into sturdy drums for the safe, economical packaging and shipment of vital replacement parts and an ever-increasing variety of manufactured products other than the familiar liquids — gasoline, oil, chemicals — is another of those serviceable applications of this most versatile of our metals that has contributed mightily to the winning of the war and that holds such useful promise in the peaceful world before us.

Skilled men manning machines of ingenious design carry this operation through from flat steel sheets to finished drums at a pace that would make the old-time cooper blink with amazement. By the millions, steel drums, barrels, other containers come off the lines of the J&L Steel Barrel Company and other barrel plants. Here is production of handmade quality with machine speed; the steady rhythm of progress that is a symbol of American ingenuity and enterprise.

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J & L STEEL BARREL COMPANY
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CONTROLLED QUALITY STEEL FOR WAR AND PEACE

J&L STEEL

ON AN ORIGINAL DRAWING AND SKETCHES MADE AT J&L STEEL BARREL PLANT AT BAYONNE, N. J. BY ORISON MACP...ASON

WAR DRUMS

"Canning" airplane engines for shipment is becoming commonplace practice. Starters, generators, instruments and cylinders are among the items now packed with desiccants in hermetically sealed steel drums to afford complete protection against breakage, dust and moisture during shipment by sea or air, or storage in transit. This new technique, developed by J&L Steel Barrel Company with Air Technical Service Command, has become of increasing military importance, now that total war has moved into the salt-laden humidity and heat of the Pacific climate, which, overnight, breeds sporadic growths of fungi and mildews.

Other "canned" war items for which J&L Steel Barrel Company has made special containers are bagged powder, smoke pots, 75mm. shells. The barrel company also developed a large, smokeless powder box and produced them in quantity. Bomb fins and bomb fin crates are other war products of J & L barrel plants in addition to their regular line of products.

Mortar shell program was speeded by J&L Steel Barrel Company's development of new mass production precision technique for making base discs for 4.2-inch mortar shells, at half cost of handmade discs.

Army chapel seats, oil drums with planks laid across them, in a tent, held many personnel on the European Front, until the boys built a church with salvaged materials, wrote Maj. J. H. Cook to LIFE magazine.

Empty drums for GI bathtubs are popular in S. Pacific, also for heating stoves and, locked end to end, as storm culverts.

How to retain glycerine, which has a genius for seeping out of tightest coopered wooden barrel, was answered about 1906 by appearance in Europe of a steel barrel built along bulgy lines of familiar wooden barrel. American petroleum industry, with products having a highly seepy nature, was quick to adopt new container. But the bulge or "bilge" shaped barrel soon had a formidable rival, the drum type barrel, with straight sides, embossed hoops, to strengthen and make rolling easier.

Demand for "one-trippers," or containers that need not be returned, opened wide a door to endless new uses for the light-weight, inexpensive steel drum, as the bilge type steel barrel must be made of heavy steel to maintain its barrel-like contours.

Barrels from strip mills, as well as from forests, from steel barrel plants, as well as from cooperage shops is the course barrels have traversed in 40 years. Today barrels made of steel sheets are produced with special presses and machinery (see illustration), as against the method of skilled coopers, building each barrel by hand. J&L Steel Barrel Company has plants of most modern type in Bayonne, Cleveland, Kansas City, Lake Charles, New Orleans, Philadelphia, Port Arthur, St. Louis.

Five Processes that Profit by Hooker Anhydrous Aluminum Chloride

1. Alkylation or Condensation
2. Cracking
3. Refining
4. Polymerization
5. Isomerization

Here are five common applications of Hooker Aluminum Chloride as a catalyst in the petroleum field.

1. Alkylation or Condensation of paraffins with olefins to manufacture motor fuels; of aromatics with higher olefins or alkyl halides; to synthesize pour point depressants for lubricating oils.
2. Cracking of high-boiling hydrocarbons to manufacture gasoline.
3. Refining by decomposition of organic sulfur compounds by polymerization of gum forming constituents.
4. Polymerization of low-boiling hydrocarbons to manufacture motor fuels and lubricants.
5. Isomerization to manufacture branched paraffins of high anti-knock value, to effect ring closure of aliphatic hydrocarbons, to confer increased aromaticity.

If these processes are included in your operations or if you have any others where Aluminum Chloride is used as catalyst, it will pay you to use Hooker Anhydrous Aluminum Chloride. Uniform high purity of this Hooker Chemical accounts for its wide spread popularity in the petroleum field. For consistently dependable Anhydrous Aluminum Chloride, specify Hooker.

PHYSICAL PROPERTIES

Aluminum Chloride, Anhydrous—$AlCl_3$

Molecular Wt.	133.3
Solubility, gms/100 gms solvent	
Nitrobenzene	26.6 at 20°C
Orthonitrobenzene	22.6 at 20°C
Heat of Solution	550 small cal./gm. min.
Description	Gray, crystalline solid in three sizes
Analysis	
Aluminum Chloride	99% Min.
Iron	0.1% Max.

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Caustic Soda Chlorine
Antimony Trichloride Muriatic Acid
Sodium Sulfhydrate Sulfur Dichloride
Sodium Sulfide Aluminum Chloride

8460

tinuous one, requiring only the addition of low-pressure steam to the gases leaving the first zone. This steam cools the gases to a temperature satisfactory for the reaction in the second zone. Undesirable gases such as sulfur dioxide, carbon oxysulfide, and carbon disulfide are either absent or present in only small amounts. A bibliography of 7 references is included.

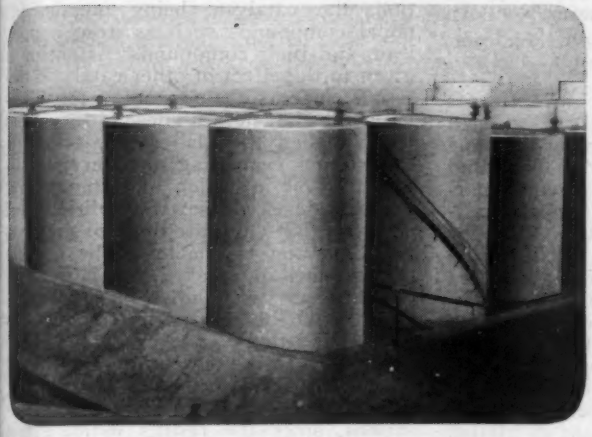
Evaporation Losses of Aviation Gasoline in Standing Storage. P. GRANDONE, *U. S. Bur. Mines Report of Investigations* 3701, May, 1943.

The determinations of evaporation losses of aviation gasoline were made in seven 50,000-barrel tanks by direct gauging. It was possible to check gauges repeatedly to 1/16-inch, which corresponds to a variation of about 0.02 percent of the tank capacity. The water in the bottom of the tank was gauged. Temperatures were measured at a point 5 feet below the surface, at a point 5 feet from the bottom of the tank, and at a point midway between the top and the bottom. Test A was on blended aviation fuel stored in a cone-roof tank, having a vapor space of 8000 cubic feet. Evaporation loss for the whole 6 months of the test was 470 barrels or 0.93 percent of the volume of gasoline stored. Gravity decreased from 72.1° to 71.7° API, and the initial, 10 percent and 20 percent points of the distillation curve were raised 10, 12 and 8° F. respectively. Tests B and C were made in modified breather-roof tanks. These roofs comprise a flexible steel diaphragm across the top of the tank, welded at the edge to the top of the tank shell. The roof is free to flex up and down as the air-vapor mixture in the tank expands and contracts. The fully expanded, domed roof added 8000 cubic feet to the volume of the tank. The tests on tank B indicated a loss of 63 barrels or 0.12 percent in 3½ months. Tank C in a period of slightly less than 5 months lost 184 barrels or 0.36 percent. The distillation points of the gasoline in tank B increased 4, 2, and 2° F. respectively, while those in tank C showed smaller increases, represented by rises of 1°, 2°, and 1° F. Loss from neohexane was tested in tanks D and E. D had a cone roof but was also equipped with a water spray on the roof. The loss in tank D was about 200 barrels a month compared to 57 barrels a month from tank E, which had a breather roof. In general, the physical and chemical properties of the fuels were little affected by the losses in storage.

British Research on Petroleum Substituents. Hydrogenation of Coal. R. M. BRIDGWATER, *Petroleum (London)* **8**, No. 2 (1945) p. 22.

The object of the experimental work at the University of Birmingham was to determine the types of British coal most suitable for hydrogenation. Standard conditions of time, temperature, and pressure were maintained in most of the experiments. Somerset coal, of which 81.7 percent was carbon, 5.3 percent hydrogen, 1.5 percent sulfur, and 1.5 percent nitrogen, gave an increased oil yield of 6 percent when pressure treatment was increased from 140 to 240 atmospheres. It was observed that increasing the ash content of certain coals improved the yield of oil, and that ammonium

AMERICAN EQUIPMENT!



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General American is prepared to build equipment in any steel, alloy or other metal. Pressure vessels are designed and tested to any required standard—ASME, API-ASME, State, or other Codes . . . field-erected storage tanks are built to customers' specifications or API Code.

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molybdate as a catalyst reduced gas formation, especially from coals of low grade. The smallest percentage of insoluble residue was found at 445-450° F. Using a paste of coal and low-temperature tar increased the conversion of coal to liquid. Various catalysts lowered the temperature of the initial reaction and increased the speed. Many tin compounds were active catalysts in such amounts as 0.1 percent. A small amount of titanium oxide in iron oxide acts as a promoter, Alkaline substances are negative catalysts. Chlorine produced the lowest yield of insoluble material, iodine the best yield of distillable oils. Catalysts had little effect on the amount of phenolic and basic substances produced. From various runs it appeared that coal to be suitable for hydrogenation should contain less than 87 percent of carbon. "Partial hydrogenation" yields a mass of material that has an improved coking capacity. This would widen the range of coals that are suitable for coking and gas making. The attempt to produce diesel oil is described.

Products: Properties and Utilization

The Friction Properties of Various Lubricants at High Pressures. J. Boyd and B. P. Robertson. *Trans. Am. Soc. Mech. Eng.* **67** (1945) pp. 51-59.

The friction properties of lubricants under high pressures were determined by using a method based on work done by Bridgman. The sample to be tested was placed between two circular hardened steel anvils and the torque necessary to twist one upon the other for various amounts of lateral pressure was measured. The lubricants tested included mineral, animal and vegetable oils, mineral oil plus various additives, fatty acid derivatives, greases and solid lubricants. The results for the different lubricants were compared on the basis of shearing stress as a function of angular displacement and upon the coefficient of friction and its variation with lateral pressures. The shearing stresses increased gradually with angular displacement for both the fixed and mineral oils. For the oils listed palm oil gave the lowest average coefficient of friction and machine oil the highest. All additives increased the ability of the oil to withstand shearing action. Stearic acid gave the lowest average coefficient of friction of any material listed. Although its shearing qualities were not unusual at the higher pressures, it was exceptional in the pressures range below 200,000 psi. Zinc oxide- and calcium-base greases showed much the same shear characteristics. Each showed a gradual increase in the coefficient of friction with increasing pressure. Colloidal graphite gave relatively low average coefficient of friction, but there was a tendency for the friction properties to become less satisfactory as the shearing operation proceeded under pressures above 200,000 psi.

Factors Causing Lubricating Oil Deterioration in Engines. R. E. Burk, E. C. Hughes, W. E. Scovill, and J. D. Bartleson. *Ind. & Eng. Chem., Anal. Ed.* **17** (1945) pp. 302-9.

The service requirements of lubricating oils are so varied as to make their refining and testing extremely difficult. Indeed, the service performance of an oil is a very vague term. The complexity of factors causing the deterioration of lubricating oils in an engine has necessitated a widespread use of engine tests for oil evaluation. However, it is obviously desirable to provide a laboratory method that can be correlated with engine tests. The deterioration of lubricating oil in internal-combustion engines is caused largely by oxidation. It is shown that these reactions are primarily catalytic at the engine temperatures in question, the catalysts being metals and metal compounds such as iron, copper, lead, and their compounds. Attention is given to the effect of other catalytic materials, such as components of the blow-by gas in the engine. These observations were applied to a laboratory test procedure for evaluating the service stability of oil in which an attempt was made to develop a set of conditions and catalysts that duplicate those of the present Chevrolet engine test. The degrees of reproducibility and of correlation with engine results are shown in detail. Correlation of the test with four oils has been found to be good except upon the point of bearing corrosion. Additional procedures are described for determining the tolerance of oils to more severe conditions, since the results indicate that the above conditions and catalysts are not universally suitable. The apparatus is described in detail, as well as its use in the test. The results of the work are presented in six tables and eleven figures. A bibliography of 16 references is appended. *(Full text of this article is scheduled for early reprinting in* Petroleum Refiner.)

Engine Cylinder Lubrication and Porous Chromium. R. Pyles. *Proc. Am. Electroplaters' Soc.* June (1944) pp. 136-48.

Lubrication of engine cylinders is discussed and it is stated that a porous chromium coating on the cylinder wall permits higher speeds and increased loads because of a smaller net contact area, higher thermal conductivity, and high melting point. The porous chromium surface results in better lubrication than a smooth cylinder-wall surface for the reason that on the power stroke the top piston ring does not wipe all the oil off the cylinder walls. The pores in the coating retain some oil that maintains lubrication. Photographs of drops of oil on steel, iron, plain chromium, and porous chromium surfaces are included. The spreading of the oil is more rapid and extensive on the porous chromium surface than on the others. This appears to be the result of capillary action. Spreading is more rapid on surfaces having a channel type than of surfaces with the pin-point type of porosity.

Determination of Water in Liquid Petroleum Fractions. O. T. Aepli and W. S. W. McCarter. *Ind. & Eng. Chem., Anal. Ed.* **17** (1945) pp. 316-17.

Small amounts of water (0 to 60 p.p.m.) in gasoline, naphtha, and electrical insulating oils can be determined

PLANT WINS HAND!

Photos show Taylor Accuracy at work for Utah Oil Refining Company

FEW people knew that the Army had ace-in-the-hole refineries inland to assure an uninterrupted flow of aviation gasoline for Pacific warfare even if Japs bombed the West Coast refineries. The Utah Oil Refining Co., Salt Lake City, met the strategic requirements and volunteered to expand its capacity to take on a liberal share of this program.

For many months the expanded facilities, owned by D.P.C. and managed and operated by Utah Oil, have been turning out thousands of barrels of 100-octane gasoline daily. Furthermore, it is rated as one of the most efficient aviation gasoline plants in the country. Naturally we take great pride in the part played by Taylor Instruments in attaining these production achievements.

Following are the general classifications of Taylor instruments used:

Remote Pneumatic Transmission Systems, using pressure, mercury-manometer flow, liquid level and differential pressure instruments as transmitters (see illustrations). Receivers include Fulscope Recording Controllers with Automatic Reset—some with second pen recording only; Fulscope Pneumatic-Set Controllers, with pressure or liquid level resetting flow; numerous one- and two-pen Recorders.

Rate of Flow: Mercury-manometer type Fulscope Indicating and Recording Controllers, and plain Indicators.

Pressure: Fulscope Indicating and Recording Controllers; and plain Recorders.

Pneumatic-Set Controllers: Liquid level or pressure resetting flow Controllers.

Automatic-to-Manual By-Pass: Both internal and external forms.

For full details, write Taylor Instrument Companies, Rochester, N. Y., or Toronto, Canada. *Instruments for indicating, recording and controlling temperature, pressure, humidity, flow and liquid level.*

ISO-BUTANE TOWER FEED HEATER STEAM FLOW CONTROLLER (left)
REBOILER STEAM FLOW TRANSMITTER (right)

COMPRESSOR SURGE DRUM OFF-GAS FLOW TRANSMITTER (left)
COMPRESSOR DRY DRUM PRESSURE CONTROLLER (right)

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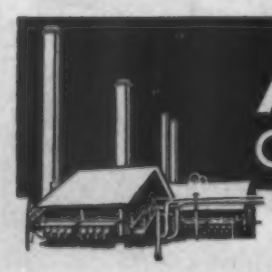

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by the Karl Fischer reagent through the use of a specially designed apparatus that effects the total exclusion of atmospheric moisture during sampling and titration. The method is not applicable to gasoline containing tetraethyllead for the reagent is consumed by the Ethyl fluid, giving erroneous, high values. The apparatus is described and pictured and the procedure is given in detail. Tabulations of results presented indicate that the method is reasonably reproducible and accurate.

Refinery Safety Guide

As a safety guide for refinery management and supervisory personnel during the war period, a 175-page manual entitled "Wartime Recommendations for Refinery Inspections" has been prepared by the Facility Security Division of the Petroleum Administration for War, at the request of the Committee on Protection of Petroleum Facilities of the Petroleum Industry War Conucil at its March 13, 1945, meeting.

The document, which contains 57 pages of charts, diagrams and illustrations in addition to text, is based on the "Tentative API Code of Good Practice for Refinery Inspection Procedure," which was being assembled by the Subcommittee of Refinery Inspection Supervisors of the American Petroleum Institute at the outbreak of the war.

The manual is not intended to be applicable to equipment subject to state or federal government regulations, such as marine equipment, power boilers, or other apparatus specifically defined by law.

The preface sets forth:

"It should be emphasized that these data have of necessity been hurriedly assembled and there have been possible omissions. However, it is the feeling of all those participating in the work that the accuracy is of such high order that there is justification in submitting it to the industry as a workable document.

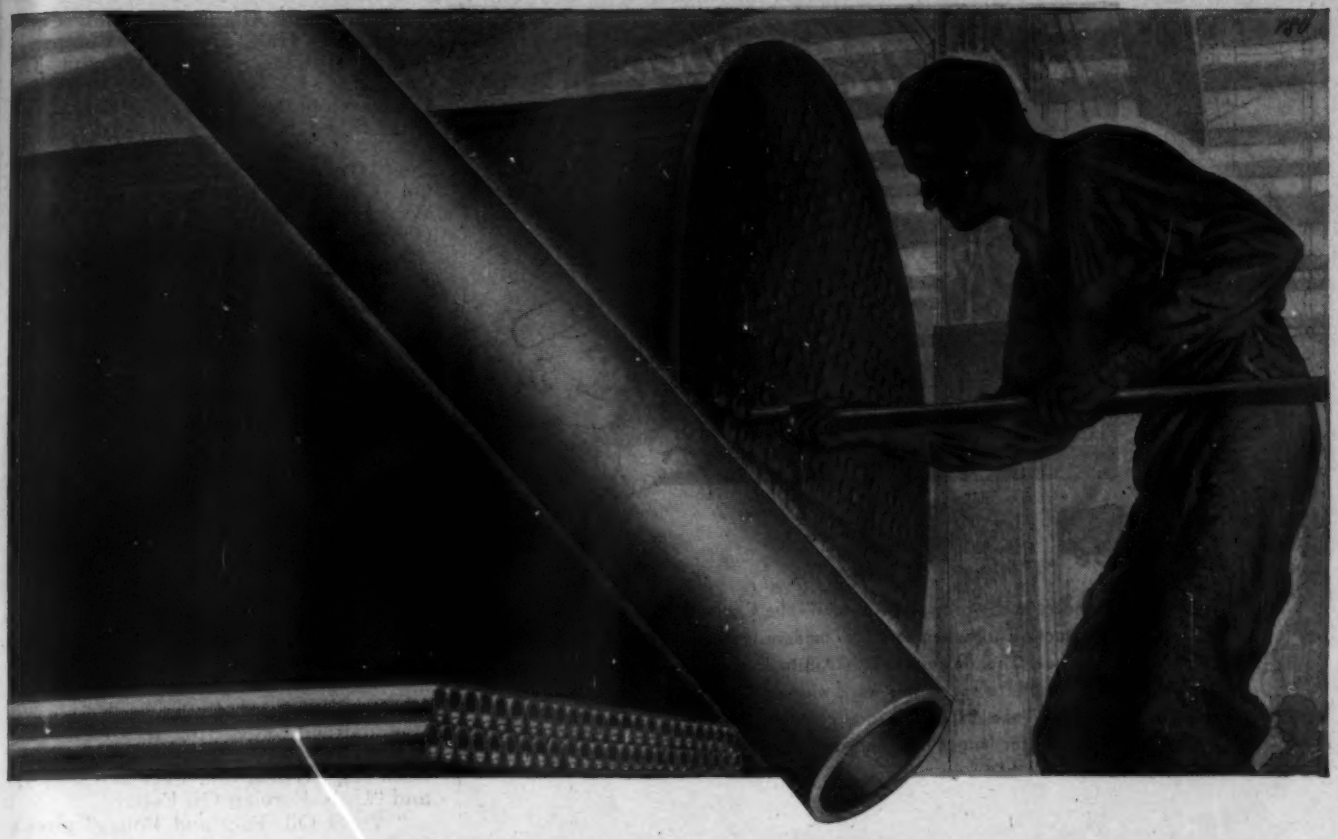
"It is recognized that due to the large variety of equipment in general use, the scope of this recommendation must be general in nature. There is no intent to discourage methods which may be appropriate for special processes and which may not be covered by this document. The manual is prepared only as a general guide for independent inspection procedures with the thought of improving the standards of inspection, to the end that greater safety and continuity of operation may be achieved."

The manual is divided into four sections — Process Equipment, Electrical Equipment, Instruments and Fire Prevention Equipment. Under the heading of electrical equipment, a certain amount of discussion is devoted to the care of prime movers and other mechanical equipment. It was felt necessary to discuss their inspection, the editors state, because of their intimate connection with electrical generating equipment.

Under each section, the scope, organization, methods of inspection, determination of limits, methods of repair and miscellaneous items are taken up in their respective order.

More than a score of industry representatives collaborated with PAW officials in the preparation of the document. They include:

F. A. Birely, Sun Oil Company; F. B. Bluhm, Sinclair Refining Company; W. L. Bowler, The Pure Oil Company; F. C. Braun, Gulf Oil Corporation; J. K.



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Bridgeport also offers Arsenical Muntz*— recommended to resist corrosion from sulphur bearing oils and gases and dezincification from corrosive waters; 70-30 cupro nickel—for conditions involving alkaline compounds and higher operating temperatures; red brass—for use where circulating water is exceptionally corrosive.

In refrigeration systems and other applications where severe double corrosion problems exist, Bridgeport's Duplex Tubing is recommended. It is supplied in many combinations such as Admiralty copper, Cuzinal (aluminum brass), red brass, Muntz, cupro nickel, and Duronze IV (aluminum bronze) with stainless, aluminum, monel metal or steel as required to meet existing conditions.

Contact our nearest Bridgeport Office for technical service to help you reduce untimely losses from severe corrosion. Write for our 112-page Condenser Tube Manual containing technical information about modern tubing alloys, corrosion research data, suggestions for increasing tube life and other important information.

**U.S. Pat. No. 2118688*

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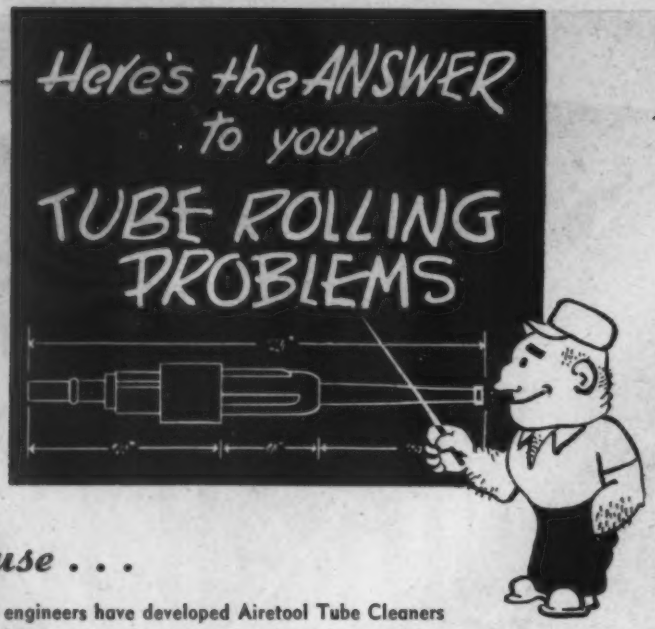

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Deichler, The Atlantic Refining Company; H. G. Hall, The Texas Company; W. A. Howard, Socony-Vacuum Oil Company; F. L. Newcomb, Standard Oil Development Company; T. D. Radcliffe, Standard Oil Company of California; T. V. Sheehan, Standard Oil Company (Indiana); Dan Smith, Standard Oil Company (Indiana), and H. F. West, The Standard Oil Company (Ohio).

Advisers on individual sections were E. J. Grace, Sun Oil Company; W. A. Hagerbaumer, Socony-Vacuum Oil Company; H. F. Moore, Standard Oil Development Company; J. A. Pellettere, Gulf Oil Corporation; M. H. White, The Atlantic Refining Company; C. A. Williams, Sinclair Refining Company; C. M. Hoag, Union Oil Company; E. J. Nopper, Sun Oil Company, and L. E. Priester, The Texas Company.

PAW officials who assisted include Frank A. Epps, William K. McCoy and Frank S. Proctor, Facility Security Division, and Franklin G. Wilson Refining Division.

World Oil Policy

The Petroleum Industry Research Foundation, Suite 316, 122 East 42nd Street, New York 17, has published two booklets, "World Oil, Fact and Policy," and "U. S. Foreign Oil Policy."

"World Oil, Fact and Policy" gives a realistic analysis of the Anglo-American oil agreement and the situation with which it deals. The booklet is an attempt to report and record the settled thinking of the petroleum industry on the subject.

"U. S. Foreign Oil Policy" is concerned with the wider context of foreign policy in which the foreign oil program will find its definition and its meaning. Basically, these two points of view are one—the welfare of the American petroleum industry and the American nation are alike at stake.

Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, Illinois, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only one gram quantities, please inform the Registry.

Cerotic acid
Glutaronitrile
Dihydrofurane
Octadecene-9
pXenylisocyanate
2,3-Dimethylphenol
2,6-Dimethylphenol
Coronene
2,3,8,9-Dibenzocoronene
Phenyl thiourea
Phenalone
3,4,9,10-Dibenzperylene
Thioformamide
5-Amino acridine
2-Brompropene
2,6-Dimethylaniline
2,3-Dimethylaniline
1-Hydroxyanthraquinone
1-Hydroxyacridine
2,4-Difluorophenol

Upson Alloy Studs stand up long after ordinary studs fail

With refineries pressing every unit for greater output, a stud that has the stuff to stay in service longer is sure to get many emergency calls. And where stud failures have caused serious "off stream" time, the call is for Republic Upson Alloy Studs.

These studs give you an extra measure of high resistance to severe temperatures and pressures. They have extra staying power under highly corrosive conditions. They have extra strength to withstand heavy wrenching.

All these performance qualities are specially produced to a high degree in Upson Alloy Studs. And the 90-year record of Upson Quality, combined with Republic's unequalled experience in alloy steel making, stands solidly behind them.

Don't wait for a stud emergency to force your hand. Get the jump on stud failures that cause "off stream" periods, and extra replacement costs. Standardize on Upson Alloy Studs now.

REPUBLIC STEEL CORPORATION
BOLT AND NUT DIVISION • CLEVELAND 13, OHIO
Export Department: Chrysler Bldg., New York 17, N. Y.

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BOLTS AND NUTS

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This quick drying iron repair cement, applied tonight, can be safely trodden on or wheeled over tomorrow morning. What's more, patches made with it stick firmly in place—and *last*. For Smooth-On No. 7B Quick Patch Cement expands slightly as it hardens, adhering tightly to surrounding surfaces.

Cracks, holes and ruts in concrete *never stand still*. Don't wait for them to spread and enlarge and cause accidents — start using Smooth-On Quick Patch NOW. Inexpensive. Easy to use. Just mix to a putty with water and apply. Order Smooth-On No. 7B Quick Patch in 5-lb., 25-lb. and 100-lb. sizes.

FREE QUICK PATCH FOLDER, REPAIR HANDBOOK

Send coupon for descriptive Quick Patch folder and receive also the free 40-page Smooth-On Repair Handbook showing ingenious repairs to plant and home equipment made with the other Smooth-On Cements. 170 diagrams. Pocket size.

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About EQUIPMENT—SERVICE Suppliers

Major John Ed Cooper, for the past three years with the Air Technical Service Command of the United States Army Air Forces, has resumed his connection with the Republic Supply Company as manager of tubular sales. His headquarters will be at the general offices of the company in Houston.

Maj. John Ed Cooper

Cooper is a native of Oklahoma and was graduated from the University of Oklahoma in 1934. For several years prior to entering the armed services he represented Republic in Oklahoma and Illinois-Indiana oil areas.

Diamond-Harshaw Company Offers Catalyst Service

Diamond Alkali Company and The Harshaw Chemical Company have organized an affiliate, known as Diamond-Harshaw Company, for the purpose of offering expanded research service and manufacturing facilities for production of preformed catalysts, either pelleted or extruded, as used by the petroleum and allied industries.

The Harshaw Chemical Company has been engaged in this field for several years, and will act as the sales agent for the new company. The sales and service policy as established will be continued. Research and manufacturing facilities of Diamond Alkali Company and The Harshaw Chemical Company will be available to Diamond-Harshaw Company.

Westcott Representative Returns Office to Tulsa

W. C. Wadsworth of Westcott Valve Company has returned to Tulsa to make his headquarters after an absence of three years in East St. Louis, Illinois, company headquarters.

Stover-Stephens Company New Organization at Tulsa

W. A. Stover, chief engineer, and L. G. Stephens, chief accountant and purchasing agent for Petroleum Engineering, Incorporated, Tulsa, have resigned and formed The Stover-Stephens Company with offices in the Palace Building, Tulsa. Stephens has had 25 years experience in the field of engineering and his work covered process design and mechanical design of gasoline plants. He spent a year in Russia as supervisor of construction and some time in France making surveys of refineries. Stephens, who has been in the oil business for 21 years, is experienced in handling materials and equipment for gasoline plants and similar installations.

W. A. Stover

L. G. Stephens

Worthington Appoints Williams International Business Director

Worthington Pump and Machinery Corporation, Harrison, New Jersey, has appointed S. Riley Williams director of international business. He will be responsible for administrative director of foreign and export activities and will supervise the operation of the corporation's associated companies in foreign countries.

S. R. Williams

A complete organization is now prepared to revive the company's international business inter-

"GUNITE"
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because you will need one to enable you to MAKE GREASE AND BLEND OIL

by its more scientific and less costly process.

Combining oils of various viscosities to effect a homogeneous blend.

To produce greases of various combinations where dry additives can be uniformly dispersed and to produce a fibre grease in which the oil bleed is materially retarded.

Where it is desirable to incorporate dry or liquid substances into oil or grease combinations, this is accomplished by reducing all components to their smallest dimensions and then homogenizing by an entirely new and more scientific process which has been adopted throughout Industry on products never before thought susceptible to homogenization.

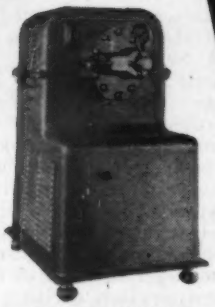
The FLOW-MASTER can be profitably used in making many new products such as Wax and Asphalt Emulsions, Insecticides, Sprays, Coal Oil Emulsions, etc.

Bunker C Fuel when homogenized by this more scientific FLOW-MASTER process will produce better combustion and there will be much less settlement in storage tanks.

THE FLOW-MASTER PUMP

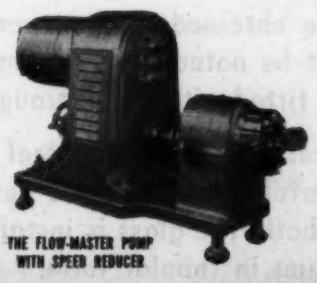
Here is a pump that really does things. It will not only handle anything that can be pumped, but it is equipped with a simple wear control mechanism that will maintain volumetric efficiency under all normal wear conditions. It will meter or proportion. Works under high or low pressure—maintains high vacuum and also maintains constant non-pulsating delivery. The ideal pump for the oil industry. Send for literature.

There is an excellent opportunity for distributors in some available territories.



THE FLOW-MASTER HOMOGENIZER

THE FLOW-MASTER KOM-BI-NATOR



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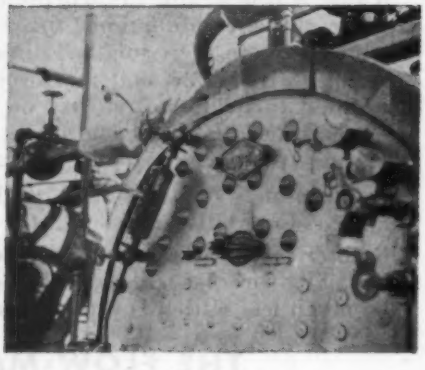

JERGUSON

THE PURPOSE of a liquid level gage is to reassure . . . or to warn, to warn through the eye. That's why it's vitally important that the gage give maximum visibility.

Without question, the JERGUSON Reflex Gage provides such visibility. The liquid in the column—any liquid—shows a dead black; the space above shows contrasting white. No better visibility can be obtained. If, however, the condition or color of liquid must be noted, we recommend our Transparent Gage, which is fitted with "see-through" glass.

Both gages are constructed of durable steel and alloy steel parts. The glass, carefully tempered, is resistant to high temperatures. And in both, the glass is installed in separate, strong strips rather than in tubular form.

JERGUSON GAGE & VALVE CO.

87 FELLSWAY SOMERVILLE 45, MASS.

7-JV-4

rupted by the war in Europe, it was said. Some Worthington representatives have already departed to reopen offices in Europe.

The company has figured extensively in the shipment of equipment for large pipe line projects in the Orient under the lend-lease program and also for foreign government requirements of heavy industrial equipment needed for economic rehabilitation. Foreign business has included pumps for emergency rehabilitation of flooded Holland areas and devastated Russian mining districts. Portable power generating units are going to many of the war-torn countries pending installation of new permanent power plants.

Williams' 25 years service at Worthington has all been in the European operations, having managed several of the company's subsidiaries there. He is a member of the foreign trade policy committee of the National Association of Manufacturers.

Stuart A. Whitehurst With Allis-Chalmers

Stuart A. Whitehurst has joined Allis-Chalmers Manufacturing Company as an industrial engineering specialist, and as head of petroleum industry activities of the company's general machine division.

S. A. Whitehurst

Whitehurst is an engineering graduate from Georgia School of Technology, and entered the petroleum industry with The Texas Company at Port Arthur refinery, later serving in the terminal division of that company's New York office. Subsequently he spent eight years with Shell Oil Company as administrative assistant to the chief engineer at St. Louis. Next he was associated with Alco Products Division of American Locomotive Works as a refinery project engineer. In 1941 he joined the engineering and construction division of Jones & Laughlin Supply Company as Eastern representative with offices at New York. He later served as administrative assistant to the president of that organization at Tulsa, and then became manager of sales of the engineering and construction division.

Birch Heads Research for Harbison-Walker Refractories

Raymond E. Birch has been appointed director of research of Harbison-Walker Refractories Company, Pittsburgh, to succeed the late Fred A. Harvey. Birch has been associated with the company since 1930. He graduated in ceramic engineering from Ohio State University in 1927 and received the professional degree of ceramic engineer in 1937. For two years, beginning in 1928, he was a research engineer at Roseville ceramic laboratory for Ohio State University engineering experiment station. Here, the research was carried through which led to the development of the vacuum pressing of refractories. His other fields of investigation have included studies on applications of thermochemical mineralogy, and development work on silica, magnesite and forsterite refractories. His publications include the chapter on mag-

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Optimum Performance **is the real proof of Whitlock design and construction. Over half a century of practical experience backs up theoretical considerations and engineered design. Data on heat transfer, strength of materials, corrosion and manufacturing procedure have been proved by this half century of heat transfer equipment at work. Whitlock "off-the-board" design is the basis for thermally and structurally sound equipment — equipment that will operate properly under your specified process conditions. Send us your heat transfer problems.**

Whitlock Designs and Builds:

Bends	**Heaters**
Coils	**Piping**
Condensers	**Pressure Vessels**
Coolers	**Receivers**
Heat Exchangers	**Reboilers**

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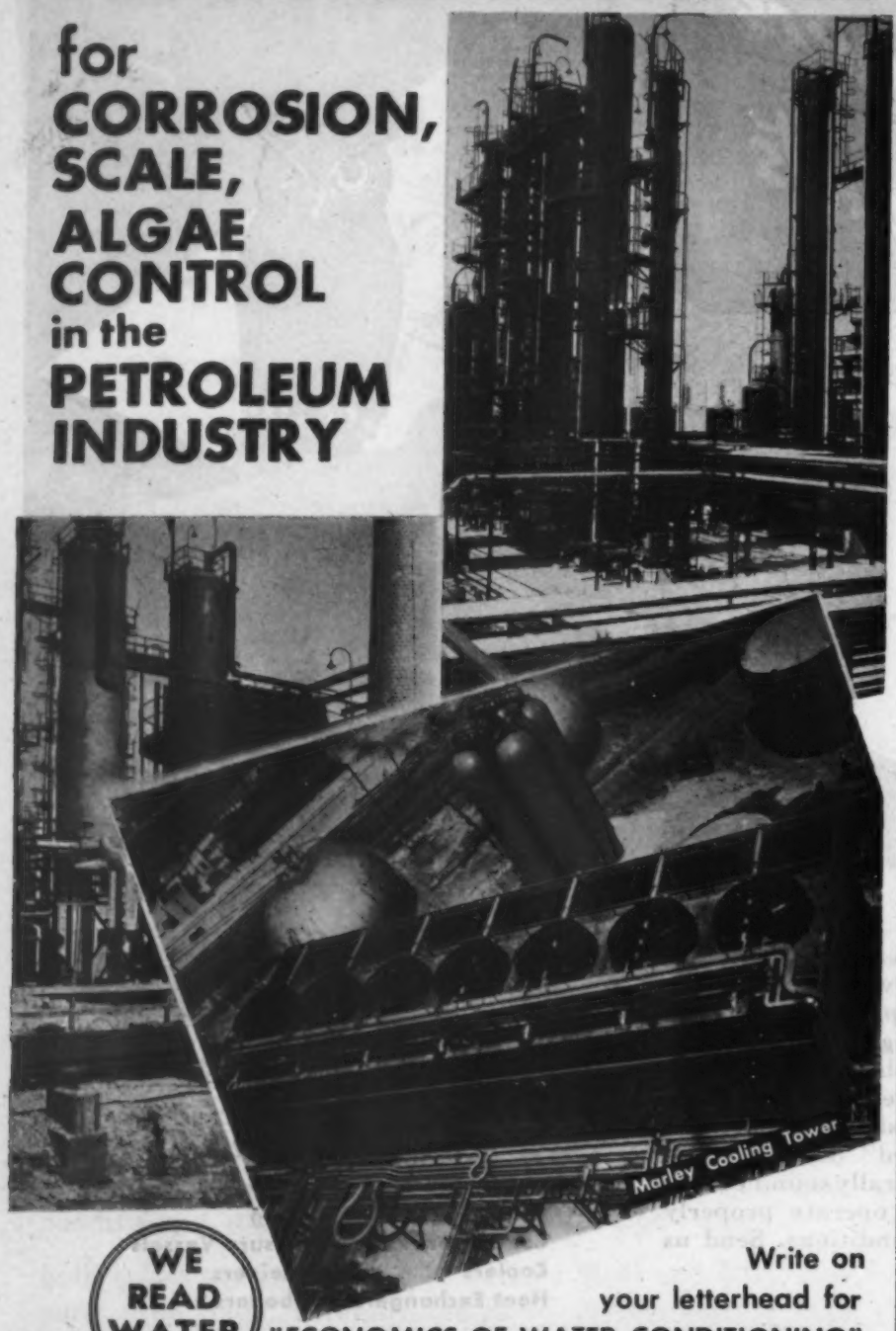
HAERING GLUCOSATES

for CORROSION, SCALE, ALGAE CONTROL in the PETROLEUM INDUSTRY



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nesite in the AIME book, "Industrial Minerals and Rocks" and a number of papers on the processing and use of refractories.

Birch has been active in the American Ceramic Society, serving at various times as trustee, chairman of the refractories division, and chairman of the Pittsburgh local section. He is a member of the Institute of Ceramic Engineers, the Society of Glass Technology, the American Institute of Mining and Metallurgical Engineers, the British Iron and Steel Institute, and is a Fellow of the American Association for the Advancement of Science. He was an organizer and is now vice-president of Pittsburgh Geological Society.

McLaughlin Heads Tube Turns Engineering Service

Carl B. McLaughlin will head the recently established engineering service division of Tube Turns, Louisville, Kentucky. He formerly was associated with the Pittsburgh, Pennsylvania office.

C. B. McLaughlin

A native of Jacksonville, Illinois, McLaughlin was graduated from the University of Illinois in 1931 and was a metallurgist-engineer with United States Steel Corporation before joining Tube Turns in 1943.

Herrick Named Sales Manager D'Este Division, American Chain

Daniel A. Herrick has been appointed manager of sales of d'Este Division of American Chain and Cable Company, with headquarters at Reading, Pennsylvania, Although this is a new division of the company, the d'Este line of automatic regulating valves, pressure-reducing valves, tank and float valves has been made by the company for some time, and Herrick has been active in the sale of these products for several years.

Spencer Lens Company Made American Optical Company Unit

Effective June 30, Spencer Lens Company became Scientific Instrument Division of American Optical Company. History of Spencer Lens Company goes back to 1837, and its interesting development is told in a handsome brochure which is being distributed in connection with the announcement of the change in corporate status. The company has been owned by American Optical Company since 1935.

Mitchell Heads Carnegie-Illinois Alloy Products Sales

Carnegie-Illinois Steel Corporation has announced the appointment of John Mitchell as manager of the products section of the alloy sales division. He leaves the position of alloy metallurgical engineer of this United States Steel Corporation subsidiary.

Murphy Directs Development For Pennsylvania Salt

Frank E. Murphy, formerly assistant to manager of research and development department, has been appointed director of development division, research and development department, Pennsylvania

KOVEN *for* REFINERY *and* PETRO-CHEMICAL EQUIPMENT

KOVEN has played an important part in the wartime development of the fast-growing petro-chemical industry and their skill and experience will continue to aid in the industry's even greater post-war advancement.

For more than 64 years, KOVEN has been designing and manufacturing chemical equipment that is known for its reliability. They have no patented process to sell and all equipment, whether large or small, is made to individual specifications in the two huge KOVEN plants.

If you need help in determining the exact equipment that best fits your individual requirements...a KOVEN representative will be glad to assist you. Moreover, this consultation will not obligate you in any way. Just call or write to KOVEN today.

Among the many pieces of KOVEN equipment are: pressure vessels, extractors, mixers, stills, condensers, kettles, tanks, containers, stacks, coils. A. S. M. E. and A. P. I. code welding.

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PLANTS:
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EVEN IN THESE *Rough Places*

WESTON THERMOMETERS

are ALL-METAL for ALL-ROUND ruggedness!

In tough spots like these, and many others too, *Weston All-Metal Industrial Thermometers* withstand shaking up without breaking down. Even the severe vibrations of pumping units or Diesel engines do not affect the long-term stability of Weston Thermometers.

Basic to their *all-round ruggedness* is an all-metal construction that insures sustained accuracy (within 1% full-scale) over long periods of time. There are no liquids, gases, capillaries or other troublesome parts. Simply an all-metal temperature element safely sheathed in a rugged stainless steel stem.

Weston All-Metal Thermometers are available in scale lengths 6", 9", 12" . . . stem lengths from 2½" to 48" . . ranges from – 100°F to + 1000°F. Literature gladly sent on request . . . Weston Electrical Instrument Corporation, 655 Frelinghuysen Avenue, Newark 5, New Jersey.

Weston *All Metal* THERMOMETERS

Salt Manufacturing Company, Philadelphia. In his new position Murphy will have charge of chemical engineering activities including pilot-plant operations, engineering research and related fields of work. He will be located at Whitemarsh Research Laboratories though a substantial amount of the work involved will be carried out at various plants of the company.

Hanlon-Buchanan European Representative Visits Tulsa

Thomas L. Barks, managing director of Barks Williams & Company, Ltd., London, England, European sales representatives for Hanlon-Buchanan, Inc., is in Tulsa discussing postwar plans with his associates.

Marco Company Moves To Larger Quarters

Marco Company has moved to larger quarters at Third and Church streets, Wilmington 50, Delaware, where it occupies a modern two-story building. Laboratory and manufacturing facilities are located on one floor, permitting streamline production, and the enlarged laboratory is being equipped with the latest in apparatus to make it one of the most complete of its kind.

Zak Assistant Sales Manager For Pittsburgh Steel Company

Carl L. Zak has been appointed assistant general sales manager of Pittsburgh Steel Company, Pittsburgh. Since January of this year he has been manager of tubular sales, and previously was secretary of Seamless Steel Tube Institute. Former connections include Youngstown Sheet & Tube Company and Globe Steel Tubes Company.

E. R. Smith has been made manager of oil-country tubular sales, having been assistant manager of that department during the past five years.

Pennsylvania Salt Adds Four to Research Staff

Pennsylvania Salt Manufacturing Company, Philadelphia, announces the following additions to its research and development staff: Dr. C. E. Inman, formerly with Hooker Electrochemical Company; H. S. Fisher, Aluminum Company of America; O. T. Aepli, Attapulgus Clay Company, and E. P. Street, recent graduate of Yale University.

Industrial Scientific Moves Houston Headquarters Office

Industrial Scientific, Houston, has moved its headquarters office and warehouse to larger quarters at 317 Nagle Street.

Foster Wheeler Corporation Gets Highest Navy Award

Foster Wheeler Corporation's Carteet, New Jersey plant recently was awarded the Army-Navy E for the sixth time. This is a distinction in that no other plant has been more highly recognized for contribution to the war effort, and only about 100 plants throughout the country have been so honored. The company's Dansville, New York plant has received the award four times, making a total of ten such awards to Foster Wheeler Corporation for production of boilers, condensers, distillers and affiliated equipment for the Navy.

NEW EQUIPMENT
...MANUFACTURERS' · LITERATURE...

FOR FREE COPIES OF MANUFACTURERS' LITERATURE OR MORE INFORMATION ON PRODUCTS DESCRIBED ON THESE PAGES, USE THE MAILING CARD INSERTED IN THIS ISSUE

1—Water Heater

American District Steam Company, North Tonawanda, New York, has announced a new instantaneous water heater, Type R, which is compact in size with a steel shell and 1¼-inch outside diameter No. 16 BWG copper U-tube removable heating element. It is low-friction-loss type for use with a gravity recirculation system, or where minimum friction loss in the water space is desirable. The steam flows through the tubes and the water in the shell. It has numerous applications in commercial and industrial buildings. It may be used also as a converter to heat water in a conventional hot-water-heating system or in connection with radiant heating installations.

ADSCO Type R

Bulletin 35-76B gives capacities, dimensions and list prices on 22 sizes available.

2—Electronic Inspection Device

Engineering Laboratories, Inc., Tulsa, has been licensed by Texaco Development Corporation to manufacture and sell "The Penetron," a device utilizing electronics and radioactivity principles for the measurement of thickness of solids, and for determining liquid level and liquid density. By its use inspection data is obtained on high-pressure pipe lines, boiler tubes, towers, pressure vessels, etc., without cutting or drilling. Readings are made in 25 seconds with over 150 inspections per working day possible. It also is used to locate interface of fluids of various densities and to determine liquid level in sealed containers.

"Operating principles cannot be discussed in great detail owing to government secrecy limitations," an announcement says. "However in operation the instrument bombards the subject object with gamma rays which are derived from a needle containing a minute amount of radium. These gamma rays travel with the velocity of light and are, in fact, radiant energy. They are not deflected by magnetic nor electric fields. The rays are scattered by the electrons of the atoms in the material being inspected. Some of these rays emerge, or are back-scattered from the material on the same side as they entered. The intensity of the back-scattered radiation increases as a direct function of the thickness of the material at the spot being measured. By measuring the intensity of this back-scattered radiation, the thickness of the material, whether it be steel, aluminum, plastic, brass, wood or any other substance, can be obtained with extreme accuracy. By the same means liquid levels and liquid densities also are obtained."

Penetron

A booklet is available.

3—Acid Cleaner

Pennsylvania Salt Manufacturing Com Special Chemicals Division, Philadelphia 7, has announced "Pennsalt PM-90," a specially prepared acid cleaning and descaling compound. Containing addition agents for surface action and inhibition, it is primarily used as a pickling-bath concentrate in electroplating shops, and as an acid cleaner for removing water scales from boilers and industrial equipment. It is packaged in 115-pound returnable carboys.

4—Mixing Jet

The Youngstown Welding & Engineering Company, 3701 Oakwood Avenue, Youngstown 9, Ohio, has designed a new type jet which uses steam, air or solution to agitate and circulate solutions in tanks and vats.

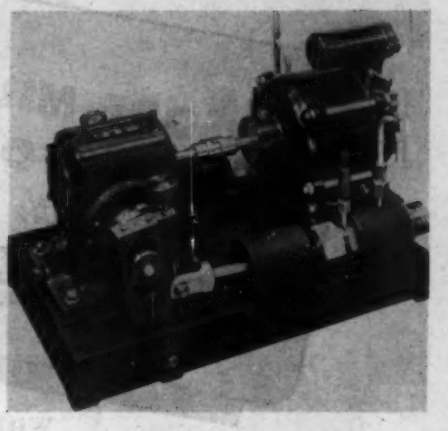
By installing the jet anywhere along the side of a tank, the company claims the entire tankful of liquid can be agitated and mixed at the same time. No special piping is necessary. Velocity of the air, steam or liquid increases as it passes through the special nozzle and expands into the bell-shaped housing of the jet. This action sucks solution from the tank through the back of the jet so that the solution at the side and back of the jet is agitated and circulated as well as is the solution in all other parts of the tank.

The unit is welded in one piece, and is available in corrosion-resistant metals as required. It has no moving parts, and can be used on any line which has 10 pounds pressure or more.

Literature and data are available.

5—Duplex Pump

Precision Scientific Company, 1754 North Springfield Avenue, Chicago 47, in collaboration with Universal Oil Products Company, has developed the "Precision-U. O. P." duplex high-pressure pump. It is a variable-stroke unit which is offered as meeting the requirements for a sturdy, continuous-duty, high-pressure, adjustable-stroke pump for use in pilot-plant operations, experimental pressure work, and for many industrial applications. Individual cylinders permit handling two different types of liquids simultaneously, or where increased volume is desired above the capacity of a single cylinder, both cylinders can be piped in parallel. Because of the compact design, these pumps are particularly adaptable to most applications where space is a premium. Design permits continuous operation and will maintain a given flow rate continuously, delivering full rated output at maximum rated pressure. Volumetric efficiency throughout the full range is over 90 percent.

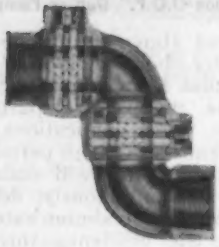


"Precision-U.O.P." Duplex Pump

6—Pulsation Damping Unit

Taylor Instrument Companies, Box 110, Rochester 1, New York, has developed a new type of pulsation damping unit, which it offers as universal in application. It delivers an output pressure that is essentially equal to the average flow of the pulsating input pressure. It has no moving parts, nor is there need for any external adjustment to be made. It consists of a series of alternate small capacities or volumes and orifices. As

Youngstown Mixing Jet



CHIKSAN FORMULA FOR PERFECT FLEXIBLITY:

$$BB_2 + EP = \frac{P/V}{LT}$$

BB_2 = Double Rows of Ball Bearings
EP = Effective Pack-Off
P/V = Pressure or Vacuum
LT = Low Torque

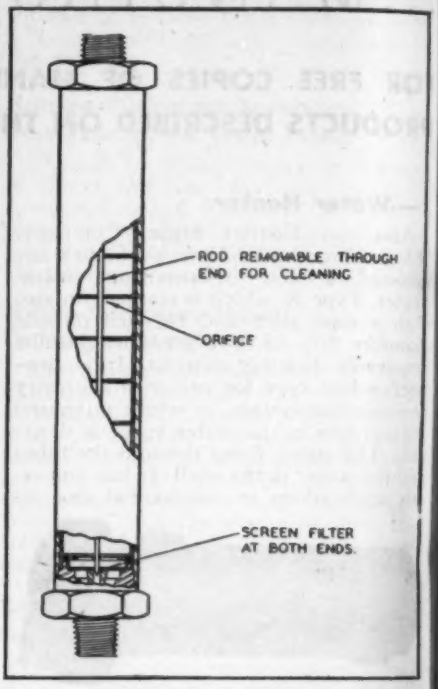
With oil wells going deeper and deeper, it may not be long until depths are stated in miles... not feet! Drillers get more miles of service per foot of rubber rotary hose by using a CHIKSAN *Ball-Bearing* Swivel as end connection (shown in photo above). You can protect your rubber hose and make it last longer, too, by using Chiksan Swivels for connection to gas, oil, air or water outlets... and on all hose reels. Over 500 different types, styles and sizes for every purpose. Write for Catalog.

Representatives in Principal Cities.

Distributed Nationally By CRANE COMPANY.

CHIKSAN TRADE MARK REG.
BALL BEARING SWIVEL JOINTS FOR ALL PURPOSES
CHIKSAN COMPANY
BREA, CALIFORNIA

For copies of manufacturers' literature or additional information on products described, use mailing card, at page 249.



Taylor Damping Unit

the pressure wave enters the device, a differential occurs across the first orifice which causes a flow through it, thus raising the pressure in the adjacent chamber. This in turn causes a flow through the next orifice, producing similar effects except with decreased intensity. While this "above-average" value of the pressure wave is making its way through the series of chambers, the pressure drops below the average value (since it is a pulsating one) causing a reversal of the flow process. Thus it can be said that the various capacities "breathe" with decreasing intensity as the waves pass through the damping unit until finally a point is reached where the pressure level lies just about at its average value. It is important therefore that each individual orifice provide the same drop for the same flow, regardless of direction.

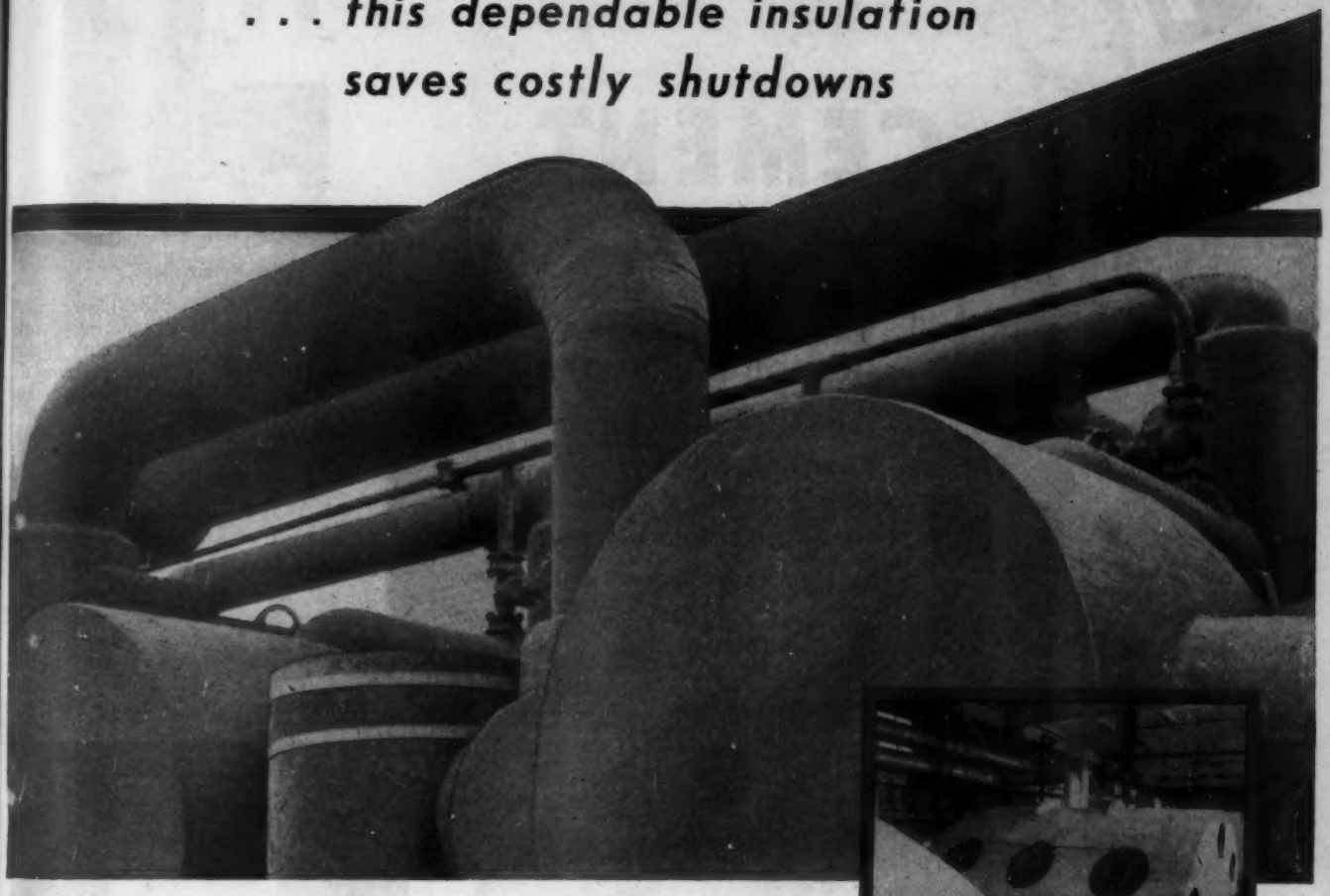
To overcome the difficulty of plugging, fine mesh screens are provided at both the entrance and exit of the damping unit. In addition, a rod which passes axially through the series of orifices can be removed, thus exposing a large orifice area for simple and effective cleaning. The device is free of gaskets and the caps are welded to the tubes to provide leak-proof construction. The unit is subjected to a static pressure test of 3000 psi and bears a working pressure rating of 1500 psi. Adapting the unit to liquid or gas service is made by using one of the two rods supplied, the selection of which is made at time of installation.

7—Return Bend

Key Company, 2681 McCasland Avenue, East St. Louis, Illinois, announces the new improved Key 7000 Type return bend fitting which, with special bull nut and plug pulling device, permits the plug to be freed from the body while the nut remains firmly held by

WHERE CONSTANT COLD IS ESSENTIAL

. . . this dependable insulation saves costly shutdowns



At Quaker State Oil Refining Corp., Farmers Valley, Pa., processing costs and downtime expenses are kept at a minimum with Armstrong's Cork Covering on all cold lines.

Continuous Operation, under severe conditions, calls for cold line insulation that won't fail. If heat and moisture get to the pipes, delicate temperature controls may be upset, equipment damaged, and refrigeration wasted. Costly shutdowns may also be required for repair or replacement of the insulation. That's why pipe covering that efficiently protects against heat and moisture through the years repays its cost many times over.

Armstrong's Cork Covering has proved highly satisfactory for cold lines serving continuous processes. The high thermal efficiency of this insulation lasts, because it's cork—and cork is naturally moisture resistant. Armstrong's Cork Covering is rigid; it won't pack or sag. It is manufactured to fit the lines accurately. It makes tight contact at every joint.

Armstrong's Cork Covering fits any standard pipe or tube from ¼" o. d. up and is made in three standard thicknesses and in special thicknesses to hold any degree of refrigeration. Armstrong's Fitting Covers provide the same tight, efficient insulation for valves, tees, ells, etc. For full information, write today to Armstrong Cork Company, Building Materials Division, 7507 Concord Street, Lancaster, Pa.

ARMSTRONG'S INDUSTRIAL INSULATION

Complete Contract Service For All Temperatures

From 300° Below Zero

To 2600° Fahrenheit

B-H No. 1 Insulating CEMENT

Your No. 1 choice for
VALVES, FLANGES AND IRREGULAR SURFACES

B-H No. 1 Cement resists any temperature up to 1800° F., even under humid conditions. Forms a permanent, rust-free bond. Withstands normal expansion and contraction —no peeling, no cracking.

B-H No. 1 Cement is easily applied—just mix with water and trowel on. Assures a neat, workmanlike job even on irregular surfaces, large or small. Keeps costs down —gives exceptional coverage—completely reclaimable up to 1200° F.

THE COUPON BELOW will bring you full information and practical sample of B-H No. 1 Cement—made of nodulated B-H *black* Rockwool and other ingredients.

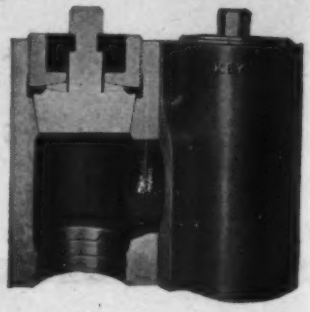
Baldwin-Hill
THERMAL INSULATION PRODUCTS

Baldwin-Hill Co., 515 Klagg Ave., Trenton 2, N. J.
Send information on products checked below:

☐ Free sample of B-H No. 1 Cement
☐ No. 100 Pipe Covering—effective up to 1200° F. (for long runs overhead, underground, Diesel exhausts)
☐ Mono-Block—the one-block insulation for all temperatures up to 1700° F.
☐ Black Rockwool Blankets (felted between various types of metal fabrics)

NAME _____ POSITION _____
FIRM _____
ADDRESS _____
CITY _____ ZONE _____ STATE _____

For copies of manufacturers' literature or additional information on products described, use mailing card, at page 249.

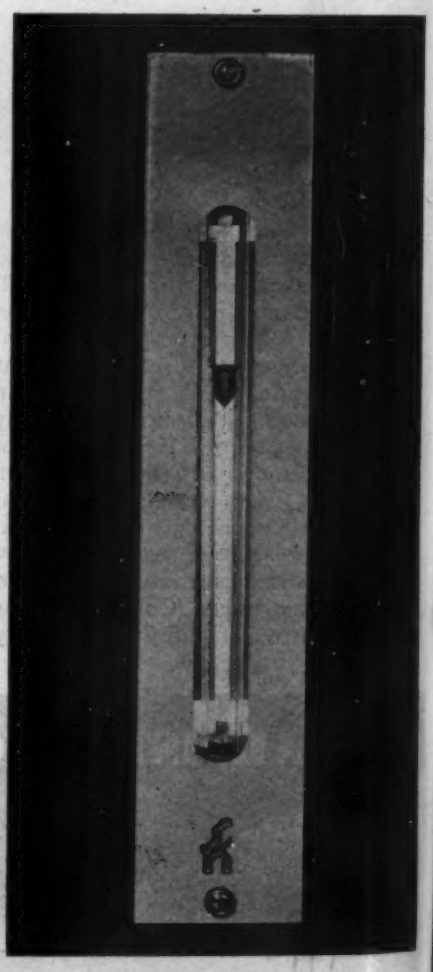


Key Return Bend

the engaging threads, localizing flash within the bend and protecting workmen. A double cone thrust ring equalizes pressure from the bull nut over the entire bearing surface of the plug, and aids in guiding the plug to even bearing across the face of the seat. The cross-over port is reinforced to give uniform stress distribution and to provide maximum corrosion allowance at points where wastage is most prevalent.

8—Panel-Mounted Rotameter

Schutte & Koerting Company, 12 South 12th Street, Philadelphia 7, has announced a panel-mounted rotameter which it says is designed to answer the growing need for panel centralization of instruments. The instrument itself is



S-K Panel-Mounted Rotameter

Fire Fighting Blizzard

by

NATIONAL FOAM

Fire is unpredictable—like the weather, but there is nothing uncertain about the man-made "blizzards" of tough, clinging, fire-smothering foam produced by National Foam. It's there when and where you want it — as a gas-tight blanket of Aer-O-Foam — to snuff out flames and prevent flashbacks.

The U. S. Navy calls Aer-O-Foam "bean soup"—with respect. Easily and quickly applied, it is a veritable blizzard of thick, tenacious bubbles smothering the immediate surface afire — without interference with other activities.

Fire strikes in season and out. Aer-O-Foam "blizzards" are available the year around.

BACK THE ATTACK
BUY WAR BONDS

Beginning of a Foam Blanket suggests an early snowfall.

NATIONAL FOAM SYSTEM, INC.

SPECIALIZING IN FOAM FIRE PROTECTION

Packard Building, Philadelphia 2, Pa.

For strength and simplicity, only two parts are used — bearing bars which carry the load and have curved slots punched ABOVE THE NEUTRAL AXIS, and cross bars, of the same cross sectional area as the slot itself, pressed into these slots to distribute the load. No rivets, bolts or welds are required, thus eliminating the possibility of loose joints. Tri-Lok flooring comes in rectangular, diagonal and U shapes with Safety Steps — ask for Bulletin 1140 — DRAVO CORPORATION, NATIONAL DEPARTMENT, 300 Penn Avenue, Pittsburgh (22), Pa. (Distributor for THE TRI-LOK COMPANY)

DRAVO

Fits Like a Glove—

HENCE KEEPS MORE HEAT IN

A KEL-BLOC high temperature insulating block is yielding enough to fit tightly around surface irregularities. Composed of high temperature, moisture resistant, long fibre black Rockwool, felted and bonded together to provide uniform density; the millions of dead air cells assure its exceptionally low conductivity.

Kel-Bloc is light in weight, easily cut and fitted to irregular surfaces and provides a ONE BLOCK INSULATION effective over a range of temperatures up to 1600°F.

Write for further information on physical properties, sizes, etc.

RECOMMENDED FOR INSULATING:

Pressure Vessels	Oil Heaters
Heat Exchangers	Dryers
Steam Accumulators	Ovens
Boilers	Breechings
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basically the company's Universal rotameter, and the panel mount has a frosted-glass aperature and is installed flush in the panel board, with the rotameter supported directly behind. Provision is made for adequate back-lighting and ready maintenance accessibility.

9—Fire-Hose Nozzle

Grinnell Company, Providence 1, Rhode Island, has developed the Grinnell "Flamebuster," a three-purpose fire-hose nozzle particularly for fighting fires in oils and other flammable liquids. It permits application of water in the form best suited for quick control, according to the nature of the fire. The operator, by shifting the valve handle, has at his disposal either spray or solid stream. Choice of high- or low-velocity spray is made by attaching the proper tip to the nozzle by means of a simple bayonet-type catch.

For extinguishing stubborn fires in light flammable liquids the low-velocity-spray tip on a 4- or 10-foot applicator discharges a wide-angle cone of evenly distributed, fine spray directly over the blaze. Fire is extinguished quickly with minimum water consumption.

For extinguishing fires in heavier oils a driving spray from the high-velocity tip emulsifies the blazing oil and renders it incapable of burning. It affords the fireman excellent protection in approaching the blaze.

For mopping-up operations on wood or similar materials ignited by oil fires and burning beyond the range of spray, the solid stream is immediately available.

"Flamebuster's" large orifices in spray tips prevent clogging, easy disassembly simplifies maintenance, and a valve of unique design provides easy operation at all working pressures.

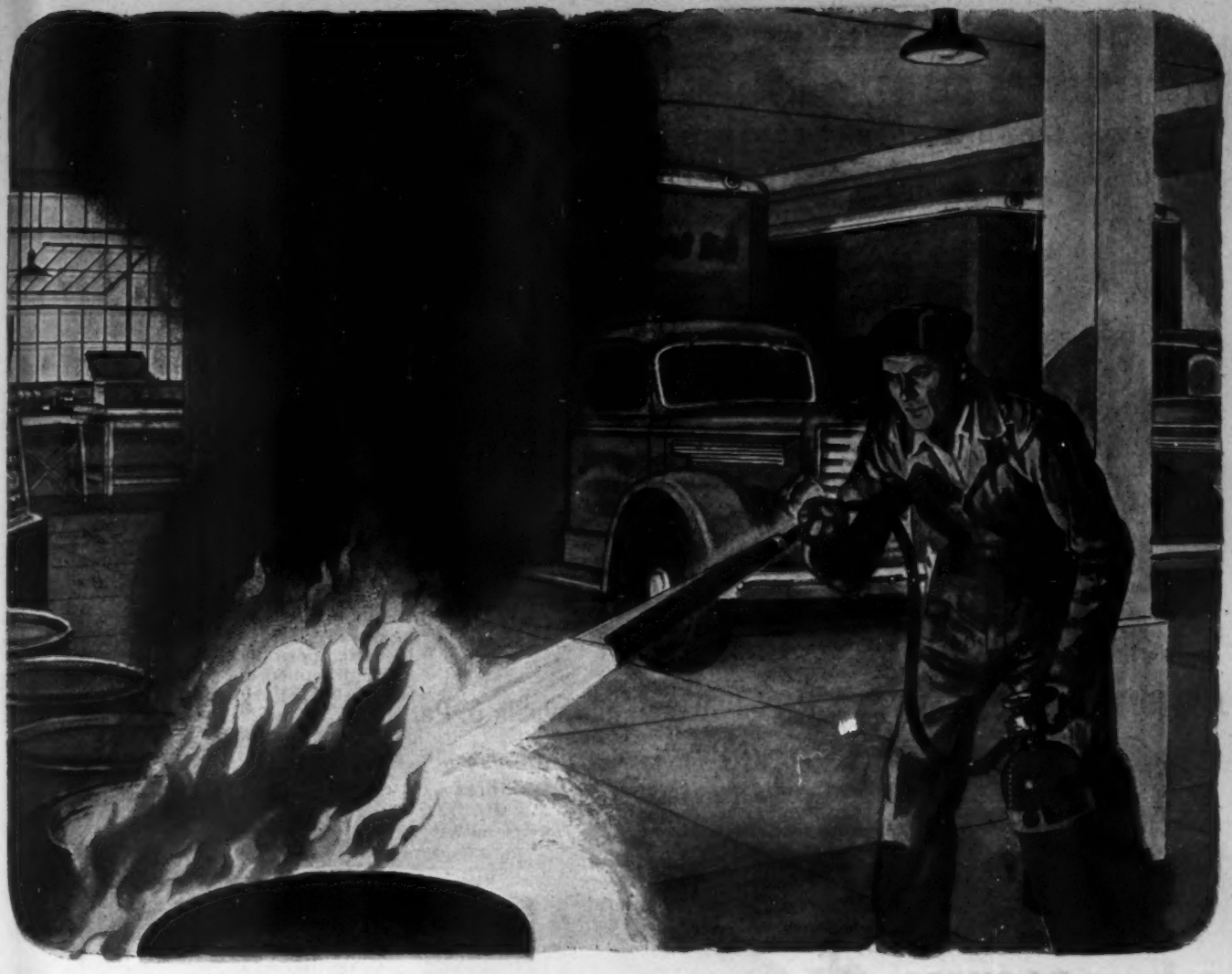
An illustrated bulletin is available.

10—Electrode Holder

General Electric Company, Schenectady, New York, has announced a new armor-clad (screw type), fully insulated electrode holder which features a head completely enclosed in a sheath of aluminum armor. This armor protects the insulation, resists weld spatter, and eliminates possibility of accidental contact with the welding circuit.

Designed to accommodate electrodes up to and including ¼-inch diameter, the holder is light in weight (15 ounces), and unusually cool in operation. A slight

General Electric Armor-clad Electrode Holder



Deadly to fire . . . and only to fire!

It's sudden death to flames, of course — in flammable liquids or electrical apparatus — but that's just *one* of the outstanding advantages of Kidde equipment.

Equally important: dry, inert carbon dioxide gas — the fast, sure extinguishing agent used in Kidde equipment — is *completely harmless* to materials and machines.

Carbon dioxide gas cannot contaminate or dilute valuable liquids. Used on electrical fires, it will not soften or water-soak insulation. It's a non-conductor too — there's no danger of short circuits, or of shock to the operator. And there's no after-fire mess to be cleaned up.

Kidde portable extinguishers for small, isolated blazes in flammable liquids and electrical equipment; wheeled units and built-in systems for major hazards — all are deadly to fire, and *only* to fire. The Kidde line includes the *right* kind of protection for every tough-fire hazard in the accompanying list . . . ask a Kidde representative for full information — he's skilled in the ways of fire protection.

* * *

KIDDE KILLS TOUGH FIRES *in Storage Rooms, Pump Rooms, Tank Trucks, Electrical Equipment, Paint Storage, Antifreeze Rooms, Pipe Line Pumping Stations, Case and Can Rooms, Control Rooms, Laboratories, and Bulk Plants.*

The word "Kidde" and the Kidde seal are trade-marks of Walter Kidde & Company, Inc.

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Lonergan

THESE STURDY RELIEF VALVES
Give *Dependable* Pressure Protection
. . . all along the line

Model "R" VAPOR TYPE for STEAM, AIR or GAS
Model "RU" HYDRAULIC TYPE for LIQUIDS

They look alike . . . but their internal arrangement is different, The Model "R"—designed for line and pressure vessel protection, has a popping chamber and control ring for steam or air service. The "RU" is adapted for use on hydraulic systems, feed water lines, pumps and tanks.

These two compact, sturdily constructed companion valves, provide generous relief capacity . . . they are suitable for many relief valve applications. The Model "RU" for example, is an effective "snifter" or condensate relief valve for steam engine cylinders.

Do not specify the Model "R" where A.S.M.E. Code requirements call for the approved lever type safety valve. Such applications indicate the use of Lonergan Model "ODP", with cap and lever.

Lonergan
GENERAL PURPOSE
BRONZE RELIEF VALVES
Models "R" and "RU"

Lonergan safety and relief valves cover a wide range of services. No matter what your needs may be, there is a completely engineered quality built Lonergan Valve to serve your purpose. Write for Bulletin 507. Let us submit recommendations for the particular inquiry or application you have in mind.

J. E. LONERGAN COMPANY, 216 N. 2nd Street, Philadelphia 6, Pa.

Lonergan

Safety Valves • Relief Valves
Pressure Gauges • Specialties

SINCE 1872—*Makers of Pressure-Safety Appliances for the Power, Mechanical, and Process Industries*

LARGE
CYLINDERS
AND BASKETS
by
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METAL

Where support against unusual weight or pressure is needed, Multi-Metal manufactures cylinders or baskets which can be fitted with cribbing of any design—custom made to suit your particular specifications. (Cylinders are finished at top and bottom with machined fittings made in our shop.)

From overgrown strainers to complete Filter Units, Multi-Metal units are made of wire or Filter Cloth over a backing of heavy Wire Cloth. Regardless of shape or design, Multi-Metal Filter Units mean greater throughput, cleaner filtrate and reduced filtration cost. Send for our interim catalog.

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All Metals

Multi-Metal
WIRE CLOTH COMPANY, INC.
1350 Garrison Ave., New York 59, N. Y.

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twist of the hand tightens or releases the electrode. While in use, the holder firmly grips the electrode at the proper angle, and good current contact is maintained. This keeps the holder cool, tends to prevent overheating of the electrode, and maintains a uniform melting rate down to a stub end. A soldered cable connection also helps the holder to remain cool. The width of the electrode slot limits the size of the electrode which can be inserted, thus preventing overloading.

11—Chasers and Holders

Landis Machine Company, Waynesboro, Pennsylvania, has developed a new chaser and chaser holder combination which not only simplifies interchanging of chasers but also imparts greater rigidity and strength to the combination to assure finer thread accuracy.

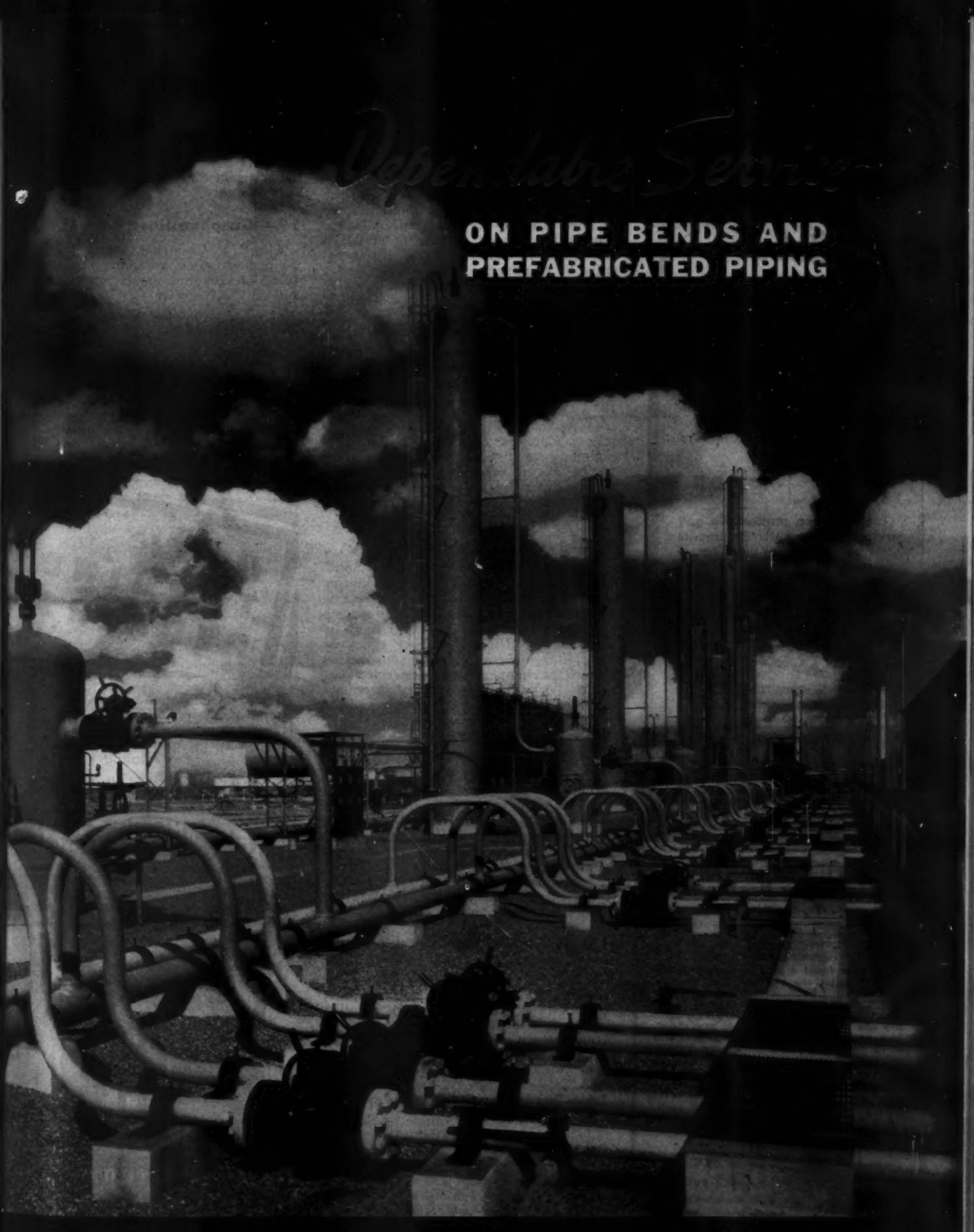
The new "Lanrac" chaser and holders employ a rack tooth arrangement to quickly locate the chaser in its approximate position. The chaser has rack teeth milled for its full length on the off-set seating surface, and likewise rack teeth are milled on the chaser clamp at the end nearest the chaser cutting edge.

Landis Chaser and Holder

When interchanging chasers, the chaser is placed on the holder in its approximate position and clamped lightly. An adjusting screw which engages the back end of the chaser clamp is then employed to advance the chaser and chaser clamp as a unit to the exact position. Elongated slots in the chaser clamp permit sufficient lateral movement of the clamp slightly greater than the pitch of the rack.

Heretofore a plain clamp has been employed to engage the dove-tail seating surface of the chaser, the chaser being backed up by an adjusting screw so located in a tapped hole in the chaser holder as to engage the corner of the chaser at the back seating surface. This arrangement made it necessary to back up the adjusting screw as much as 2½ or 3 inches, on some sizes of heads, when a long chaser was used to replace a short dull chaser. With the new clamping arrangement it is not necessary to adjust the screw more than two or three turns at any time, thus saving considerable time in interchanging chasers.

In addition to permitting quicker interchange of chasers the "Lanrac" holders and chasers provide firmer accuracy and greater strength since the chaser has approximately 40 percent increased base seating surface and elimination of the tapped hole increases the thickness of the holder from its base to the base seating surface of the chaser without increasing the overall thickness. Elimination of the open tapped hole makes for easier cleaning of the holders when changing chasers and prevents accumu-



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PIPE COILS
WELDED HEADERS

Pipe Fabricators
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COPPER SWEETENING PROCESS

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TRIANGLE BRAND

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is preferred by leading refineries because of its high copper content, dependable uniformity and exceptional purity and freedom from foreign and inert matter.

99% + PURE

Quotations on request, on any quantity required. Shipments can be made from our nearest plant.

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PLIBRICO
Jointless FIREBRICK

The Answer to Your Refractory Problems!

FOR boilers and stills—for patching and repairs—for entire walls and complete relining—Plibrico Jointless Firebrick is the dollar-saving, trouble-saving refractory that refineries everywhere are adopting.

Plibrico forms a solid, monolithic lining that eliminates the weak joints of laid-up fire brick construction. Flexo-Anchors prevent bulging. No special shapes are required; Plibrico comes in moist, plastic form and can be readily moulded to any shape. Your own maintenance men can install it or we furnish complete installation service.

For extreme conditions, there is the Plibrico sectionally-supported air-cooled wall. And the Plibrico suspended arch for boiler arches and still roofs. Both are erected without special tile or heavy castings.

These catalogs cover your requirements.

Here is the complete story of Plibrico linings, arches, air cooling, etc. Ask for your Plibrico catalog. Specify whether operating H.R.T. or water tube boilers.

PLIBRICO JOINTLESS FIREBRICK CO.
1803 Kingsbury St., Chicago, Illinois

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lation of chips and dirt under the clamping surfaces.

"Lanrac" chasers can be used with the old type chaser holders, without the use of the "Lanrac" type clamp. All new Landis Die Heads employing standard chasers 15/16-inch and wider will eventually be equipped with this new chaser holder and chaser combination on which patents have been granted, it was said.

12—Expanded Metals

Wheeling Corrugating Company, Wheeling, West Virginia, has available an illustrated booklet on its "Steelcrete" expanded metal now available in a variety of weights and meshes ranging from ¼ to 1¾ inches. The booklet illustrates a number of refinery applications including stair treads, floor grating, filter packs, fencing, ladder guards, cat walks, safety guards for machinery, window guards, and reinforcing for concrete foundations and tanks.

13—Synthetic Rubbers

Hycar Chemical Company, 335 South Main Street, Akron, Ohio, is distributing a 20-page illustrated bulletin, "Everywhere in Industry," describing its special-purpose synthetic rubbers and their industrial use. Illustrated text gives information on manufacturing processes, as well as chemical and engineering data on properties of the special products, including resistance to oils and chemicals.

14—Turbines, Pumps, Compressors

De Laval Steam Turbine Company, Trenton 2, New Jersey, has issued Catalog 1181, devoted to its complete line of steam turbines, helical gears, centrifugal pumps, centrifugal compressors, worm-gear speed reducers, and IMO oil pumps. In addition to briefly describing the equipment, this catalog tells something of the more noteworthy achievements of the company.

15—Electric-Type Controllers

The Bristol Company, Waterbury 91, Connecticut, has a 16-page bulletin describing its new "Microact" and other electric-type "Pyromaster" controllers. The several different types of controllers are illustrated and described, contact and load circuit wiring diagrams are given, and typical applications are indicated.

16—Explosion-Proof Motors

General Electric Company, Schenectady, New York, is distributing Bulletin GEA 4131, "Motors and Controls for Hazardous Location," which in addition to cataloging motors and controls in the class indicated, is a comprehensive treatise on installation of electrical equipment for operating in hazardous surroundings.

17—Water Pumps

Fairbanks, Morse & Company, Chicago 5, has issued two new bulletins: Niagara Propeller Pumps, Figure 6310, and Oil Lubricated Turbine Pumps with Enclosed Impellers. Both models are for handling large volumes of water at low heads.

18—Acryloids

Rohm & Haas Company, Washington Square, Philadelphia 5, has issued a booklet on acryloids to improve viscosity-temperature of petroleum-base hydraulic fluids, which is of interest to chemists because of possible uses of the materials in other types of hydrocarbon or non-hydrocarbon fluids.

19—Gasoline Hose

The B. F. Goodrich Company, Akron, Ohio, has issued a catalog section, No. 4010, on gasoline hose for tank-truck and tank-car service.

20—Electrodes

Air Reduction, 60 East 42nd Street, New York 17, is distributing a new electrode catalog which in 56 pages contains a combined electrode selector chart and index, and illustrated sections on mechanical properties and test. Electrodes for all welding uses and hard-facing are covered, with descriptions and

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If you need dependable Turbine repairs **in a hurry,** call us. We are completely equipped to repair and dynamically balance turbine rotors and any High Speed rotating elements in our modern shops.

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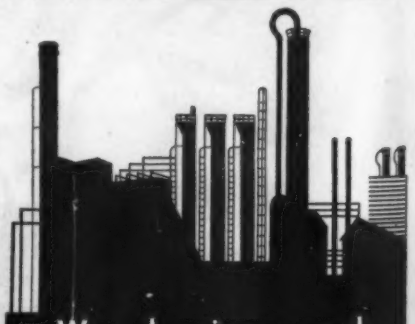

We design and construct all types of modern refining units.

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